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CAMBRIA

AXLES

AND

FORGINGS.

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CAMBRIA STEEL CO.

PHILADELPHIA, PA.

STEEL AXLES AND FORGINGS.

STEEL AXLES.

Passenger Car, Freight Car, Tender Truck,

Engine Truck, Driving, Street Car,

Mine Car, Etc.

CRANK PINS, PISTON RODS AND

GENERAL FORGINGS.

1903.

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Sep. 15, 1903
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PRESS OF
MACCALLA & CO. INC.,
PHILADELPHIA, PA.

PREFACE TO SECOND EDITION.

This edition of our handbook relating to Axles and Forgings, contains all the data of the first edition, which, however, has been corrected where necessary and revised to conform with present practice, and it also contains a considerable amount of new matter regarding the properties of, and specifications for, these materials.

Explanations have been introduced showing the superiority of steel as compared with iron for car axles, the advantages of smooth forged axles as compared with rough turned axles, and the better wearing qualities of steel axles.

A comprehensive table has been added showing all the principal dimensions and the weights of the Master Car Builders and Pennsylvania Railroad standard axles, besides which, detailed drawings of each of these axles are given on separate pages, so that reference to all or any one of them is easily made.

Other new matter which has been introduced consists of tables of dimensions, and rules for the proportions, of bolts and nuts, tables of weights of square and round bars per running inch up to 36 inches thickness or diameter, tables of weights of flat rolled steel bars per lineal foot, and various other useful tables and engineering formulæ, all of which have been carefully prepared and arranged in a manner thought best to insure accuracy and convenience in use.

GENERAL OFFICE:

Arcade Building, S. E. Cor. Fifteenth and Market Sts.

PHILADELPHIA.

Works at Johnstown, Pa.

OTHER OFFICES:

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Empire Building, 71 Broadway.

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Ingots,
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Merchant Steel,
Squares, Rounds, Flats, Plates, etc.

STRUCTURAL STEEL.

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FINISHED STRUCTURAL STEEL WORK.

Steel Work for Buildings, including Beams, Girders, Columns, Roof Trusses, etc., fitted complete and ready for erection.

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Steel T-Rails, 8 lbs. to 100 lbs. per yard.
Angle and Plain Splice Bars.
Standard and Special Track Bolts and Nuts.
For detailed information, see T-Rail Catalogue.

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of
CAMBRIA STEEL COMPANY.

Merchant Bar Steel,

Including Tire, Toe Calk, Machinery, Carriage Spring, Baby Carriage Spring, Railroad Spring, Hoe, Rake, Fork, Forging, Bolt, Rivet, etc.

Agricultural Steel and Shapes,

Finger Bars, Knife Backs, Rake Teeth, Bundle Carrier Teeth, Tedder Forks and Springs, Spring Harrow Teeth, Harrow (Drag) Teeth, Seat Springs, etc.

Plow Steel,

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Steel Discs with Rolled Bevel,

10″ to 20″ diameter for Harrows, Drills, Cultivators, etc. 23″ to 28¼″ diameter for Plows.

Pressed Steel Seats for Agricultural Implements.

For Gautier Steel Department Products not listed herein, see special Catalogue, or address,

GAUTIER DEPARTMENT,
Cambria Steel Company, Johnstown, Pa.

GENERAL INFORMATION.

Axles, Crank Pins, Piston Rods and Forgings will be furnished of carbon steel or nickel steel, as required, and are annealed or treated by our Coffin toughening Process (patented), as specified.

Particular attention is called to our Coffin Process of treatment for toughening Axles, Crank Pins, Piston Rods and other forgings.

Crank Pins and Piston Rods are also furnished oil-tempered and annealed; other small Forgings will be if desired.

For special purposes, and where the extra cost is warranted, nickel steel is well adapted for use, on account of its relatively high elastic limit and ductility, as may be seen upon reference to the specifications on the following pages.

The Cambria Steel Company early recognized the fact that, in addition to using care in the selection of the materials for making steel and the conduct of manufacture of same, it also improves Axles and similar forgings to subject them to a proper heat treatment after the forging process is completed.

As various parts of an Axle or forging are of different dimensions, and are not all worked and finished at exactly the same temperature, internal strains are produced which can only be relieved and equalized by subsequent heat treatment. When the work of forging is finished the steel does not ordinarily possess the best physical properties of which it is capable, but these can be improved to a remarkable degree by proper heat treatment thereafter.

The principal points of the theory of Chernoff, amplified and expounded by Brinell, and further studied and put into practical use by Mr. John Coffin of the Cambria Steel Company, are as follows: If steel be heated to a certain temperature W, nearly all its carbon changes to hardening carbon quite suddenly, and if the steel be cooled slowly from the temperature W, the carbon remains in the hardening state until a somewhat lower temperature V is reached, when it changes again to non-hardening carbon.

In conducting his preliminary experiments on these lines, Mr. John Coffin showed that if a small bar of axle steel be heated to the temperature W, and cooled as rapidly as possible, in water or otherwise, to the temperature V, and then allowed to cool slowly until cold, it will give a perfectly amorphous fracture. No crystal nor crystal forms will be visible under a powerful glass. It will be very tough and ductile, and have a very high elastic limit.

With a knowledge of these facts, the proper apparatus and skilful manipulation, the Cambria Steel Company is prepared to give various forms of heat treatment to Axles and the smaller forgings to produce the excellent qualities shown in the specifications presented herein.

SPECIFICATIONS.

The specifications herein give the qualities required in Forgings and Axles, and refer particularly to the sizes made by the Cambria Steel Company. The properties stated in the following specifications are the same as those which have been recently adopted as standards by the American Society for Testing Materials, which is affiliated with, and forms the American Section of, the International Association for Testing Materials.

STEEL FORGINGS.

PROCESS OF MANUFACTURE.

1. Steel for forgings may be made by the open-hearth, crucible, or Bessemer process.

CHEMICAL PROPERTIES.

2. There will be four classes of steel forgings which shall conform to the following limits in chemical composition:

	Forgings of soft or low carbon steel.	Forgings of carbon steel, not annealed.	Forgings of carbon steel, oil-tempered or annealed.	Forgings of nickel steel, oil-tempered or annealed.
	Per cent.	Per cent.	Per cent.	Per cent.
Phosphorus shall not exceed . . .	0.10	0.06	0.04	0.04
Sulphur shall not exceed	0.10	0.06	0.04	0.04
Nickel	. .	. .	. .	3.00–4.00

Specifications for Steel Forgings.—Continued.

PHYSICAL PROPERTIES OF CAMBRIA STEEL FORGINGS.

NOTE.—For properties of Axles, see the following pages.

Tensile Tests.

3. The minimum physical qualities required of the different-sized Forgings of each class shall be as follows:

	Tensile strength.	Yield point.	Elongation in 2″.	Contraction of area.	
	Lbs. per sq. in.		Per cent.		
1	58,000	29,000	28	35	SOFT STEEL OR LOW CARBON STEEL. No diameter or thickness of section to exceed 10″.
2	75,000	37,500 Elastic limit.	18	30	CARBON STEEL, NOT ANNEALED. No diameter or thickness of section to exceed 10″.
3	80,000	40,000	22	35	CARBON STEEL, ANNEALED. No diameter or thickness of section to exceed 10″.
4	75,000	37,500	23	35	No diameter or thickness of section to exceed 15″.
5	90,000	55,000	20	45	CARBON STEEL, OIL-TEMPERED. No diameter or thickness of section to exceed 3″.
6	85,000	50,000	22	45	For rectangular sections not exceeding 6″ in thickness.
7	80,000	45,000	23	40	For rectangular sections not exceeding 10″ in thickness.
8	80,000	50,000	25	45	NICKEL STEEL, ANNEALED. No diameter or thickness of section to exceed 10″.
9	80,000	45,000	25	45	No diameter or thickness of section to exceed 15″.
10	95,000	65,000	21	50	NICKEL STEEL, OIL-TEMPERED. No diameter or thickness of section to exceed 3″.
11	90,000	60,000	22	50	For rectangular sections not exceeding 6″ in thickness.
12	85,000	55,000	24	45	For rectangular sections not exceeding 10″ in thickness.

STEEL AXLES.

PROCESS OF MANUFACTURE.

1. Steel for axles shall be made by the open-hearth process.

CHEMICAL PROPERTIES.

2. There will be three classes of steel axles which shall conform to the following limits in chemical composition:

	Car, engine truck and tender truck axles. Per cent.	Driving-wheel axles. (Carbon steel.) Per cent.	Driving-wheel axles. (Nickel steel.) Per cent.
Phosphorus shall not exceed	0.06	0.06	0.04
Sulphur shall not exceed .	0.06	0.06	0.04
Nickel	. .	. .	3.00–4.00

PHYSICAL PROPERTIES.

Tensile Tests.

3. For car, engine truck and tender truck axles no tensile test shall be required.

4. The minimum physical qualities required in the two classes of driving-wheel axles shall be as follows:

	Driving-wheel axles. (Carbon steel.)	Driving-wheel axles. (Nickel steel.)
Tensile strength, pounds per sq. in. . . .	80,000	80,000
Yield point, pounds per sq. in.	40,000	50,000
Elongation, per cent. in two inches . . .	18	25
Contraction of area, per cent.	. .	45

Specifications for Steel Axles.—Continued.

Drop Test.

5. One axle selected from each melt, when tested by the drop test described in paragraph No. 9, shall stand the number of blows at the height specified in the following table without rupture and without exceeding, as the result of the first blow, the deflection given. Any melt failing to meet these requirements will be rejected.

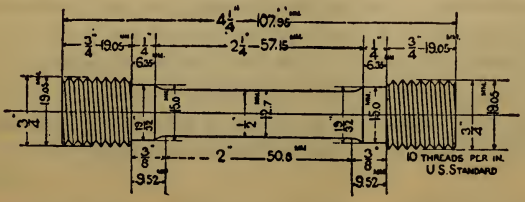
Diameter of axle at center. Inches.	Number of blows.	Height of drop. Feet.	Deflection. Inches.
4¼	5	24	8¼
4⅜	5	26	8¼
4 7/16	5	28½	8¼
4⅝	5	31	8
4¾	5	34	8
5⅜	5	43	7
5⅞	7	43	5½

6. Carbon steel and nickel steel driving-wheel axles shall not be subject to the above drop test.

TEST PIECES AND METHODS OF TESTING.

Test Specimen for Tensile Test.

7. The standard turned test specimen, one-half inch (½″) diameter and two inch (2″) gauged length, shall be used to determine the physical properties specified in paragraph No. 4. It is shown in the following sketch.



Specifications for Steel Axles.—Continued.

Number and Location of Tensile Specimens.

8. For driving axles one longitudinal test specimen shall be cut from one axle of each melt. The center of this test specimen shall be halfway between the center and outside of the axle.

Drop Test Described.

9. The points of supports on which the axle rests during tests must be three feet apart from center to center; the tup must weigh 1,640 pounds; the anvil, which is supported on springs, must weigh 17,500 pounds; it must be free to move in a vertical direction; the springs upon which it rests must be twelve in number, of the kind described on drawing; and the radius of supports and of the striking face on the tup in the direction of the axis of the axle must be five (5) inches. When an axle is tested it must be so placed in the machine that the tup will strike it midway between the ends, and it must be turned over after the first and third blows, and, when required, after the fifth blow. To measure the deflection after the first blow prepare a straight-edge as long as the axle, by reinforcing it on one side, equally at each end, so that when it is laid on the axle, the reinforced parts will rest on the collars or ends of the axle, and the balance of the straight-edge not touch the axle at any place. Next place the axle in position for test, lay the straight-edge on it, and measure the distance from the straight-edge to the axle at the middle point of the latter. Then after the first blow, place the straight-edge on the now bent axle in the same manner as before, and measure the distance from it to that side of the axle next to the straight-edge at the point farthest away from the latter. The difference between the two measurements is the deflection. The report of the drop test shall state the atmospheric temperature at the time the tests were made.

Specifications for Steel Axles.—Concluded.

Yield Point.

10. The yield point specified in paragraph No. 4 shall be determined by the careful observation of the drop of the beam, or halt in the gauge of the testing machine.

Sample for Chemical Analysis.

11. Turnings from the tensile test specimen of driving axles, or drillings taken midway between the center and outside of car, engine and tender truck axles, or drillings from the small test ingot, if preferred by the inspector, shall be used to determine whether the melt is within the limits of chemical composition specified in paragraph No. 2.

FINISH.

12. Axles shall conform in sizes, shapes and limiting weights to the requirements given on the order or print sent with it. They shall be made and finished in a workmanlike manner, and shall be free from all injurious cracks, seams or flaws. In centering, sixty (60) degree centers must be used, with clearance given at the point to avoid dulling the shop lathe centers.

BRANDING.

13. Each axle shall be legibly stamped with the melt number and initials of the maker at the places marked on the print or indicated by the inspector.

INSPECTION.

14. The inspector representing the purchaser shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture, prior to shipment.

FACTS CONCERNING STEEL TREATED BY THE COFFIN PROCESS.

(PATENTED.)

The elastic limit is increased to a marked degree.

The percentage of elongation is as great as or greater than before, and the reduction of area is considerably increased.

The ultimate strength is slightly increased.

A remarkable degree of toughness is obtained.

The steel is changed from a crystalline to an amorphous form.

The initial stresses are reduced to the minimum.

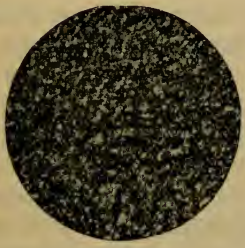
Uniformity of structure, texture and strength are obtained.

TESTS OF AXLE STEEL IN NATURAL CONDITION AND AFTER TREATMENT BY THE COFFIN PROCESS.

	No.	Tensile Strength. Lbs. per Sq. In.	Yield Point. Lbs. per Sq. In.	Elongation. Per Cent. in 2 In.	Contraction of Area. Per Cent.
Natural	3	77,800	38,700	24.0	39.0
Coffin Treated . . .	3	80,800	47,000	24.0	42.0
Natural	4	82,540	46,800	24.0	33.0
Coffin Treated . . .	4	85,900	53,000	25.0	40.0
Natural . . . Surface	8	77,130	41,100	24.0	47.0
Coffin Treated "	8	86,620	56,000	26.0	59.0
Natural . . . Center	8	76,100	39,600	24.0	41.0
Coffin Treated "	8	84,230	50,740	28.0	57.0

MICRO-PHOTOGRAPHS.

FIG. 1.



Steel before Toughening.

FIG. 2.

Steel after Toughening.

Although the increase in elastic limit, as shown by the tests, is remarkable, it is not enough to measure all the superiority of the toughened piece of steel. The untoughened pieces were coarse, crystalline, with very bright cleavage surfaces, and had that structure which breaks very easily on sudden shocks, while the toughened pieces would not break under a blow of any character until they had been distorted enough to account for breakage from the data of the tensile tests.

SUPERIORITY OF STEEL AS COMPARED WITH IRON FOR CAR AXLES.

The principal requirements for the material of car axles, is ample strength to successfully resist the imposed stresses that are ordinarily produced in regular service, combined with such other properties as will enable it to withstand exceptional stresses at times without serious results, in addition to which, the journal wear and the difficulties arising therefrom, must be reduced to the minimum.

The comparative merits of iron and steel for car axles is a question which has engrossed the attention of railroad officials and axle makers for a long period of time; until now the accumulated experience of many years has demonstrated the superiority of steel over iron for this purpose.

Steel is more homogeneous, more ductile, and more uniform, chemically and physically, than iron, besides which, it has a much higher elastic limit and tensile strength, and the combination of these good qualities in a steel axle, gives it a much greater power of resistance against the shocks, vibrations and reversals of stresses encountered in service; furthermore, being denser and harder, it possesses better wearing qualities with less friction.

Iron, on the other hand, with its lack of homogeneity, soon develops an inherent weakness in resisting the stresses induced by increasing train loads, while even the best iron axles, almost invariably develop longitudinal seams in the journals resulting in greater wear, increased friction and hot boxes. As iron is not homogeneous, the tendency of the wear and the twisting action is to separate the fibres of the metal and to develop longitudinal seams and rough spots, such that the surface soon becomes very unsuitable for the face of a journal.

While the art of steel-making has been perfected more and more year after year, the materials and skill for making the best quality of iron on the contrary, have retrograded and at the present time a good grade of iron is scarce, so that it is therefore more expensive than steel, because of the difficulty of obtaining the quality of No. 1 scrap necessary; the scrap now available being composed of inferior iron intermixed with pieces of

steel which produces imperfect welds and irregularities in the finished article.

In the early days of steel axles, it was found that there were some unaccountable breakages and fractures, although chemical analysis showed that the material was normal in these respects. The unsatisfactory behavior of steel as first used was, however, soon accounted for in several ways.

While a hammer of light weight had been sufficiently powerful for building up an iron axle from comparatively small bars by the process of hammer welding at a high heat, it proved entirely inadequate for forging the steel axle, which is not built up from small bars, but is reduced from a solid billet considerably larger than the finished axle, and at a lower temperature than that used in welding and forging iron. Furthermore, the hammer being too light, the effect was not sufficiently powerful to produce, in the axle, that homogeneous structure so essential in a forging subjected to heavy alternating stresses such as a car axle undergoes in service. The internal condition of the resulting forging was, to a certain extent, rendered visible by the appearance of the end thereof, which was concave, thus showing conclusively that only the surface metal was affected and stretched by the superficial effect of the light hammer, leaving the central portion in its rough crystalline state and the whole much weakened by internal strains. In order to remedy these defects, heavier hammers were used and these produced a distinct improvement, shown by the fact that the end of the forging was now convex, indicating that the central portion of the forging had received proper working, but the steel still gave unsatisfactory results, which further study proved was due to the internal stresses set up in the material by unequal heating and working.

In the process of forging no two blows are given under the same conditions. The metal is cooling slightly between each blow, so that it can safely be said that no two parts of an axle are forged at exactly the same temperature, and after the completion of the hammering the material is consequently in a state of initial stress. This was made evident by the action of certain locomotive axles, which, after cutting the key ways therein, thus relieving the strains in the external fibres, would often become distorted.

Temperature, then, being greatly responsible for the difficulty described,

it was sought to relieve that disturbed state by annealing, but whereas ordinary annealing relieved the forging strains, it left the material sensibly softer and lacking in the requisite stiffness, while it did not entirely eliminate the coarse structure resulting from the crystallization produced by the temperature required for forging.

A realization of the importance of having a fine structure and a high elastic limit in forgings, such as car axles which are subjected to wear as well as to severe alternating tension and compression stresses, led to further experiments which resulted in the invention of the Coffin process by means of which the elastic limit possessed by the steel before annealing is not only recovered, but is also increased, leaving the ductility and tensile strength practically unchanged, while it also relieves the forging strains and produces a fine structure.

The Coffin process, now so well known, has been applied to an immense number of axles, crank pins and piston rods which are giving excellent service on the leading railroads of America and elsewhere.

SUPERIORITY OF SMOOTH-FORGED AXLES AS COMPARED WITH ROUGH-TURNED AXLES.

Tests made upon a lot of 5½-inch x 10-inch journal steel axles to determine the relative strength of smooth-forged and rough-turned axles showed that in those of the carbon content usually furnished in axles of this size, the smooth-forged axles successfully withstood 42 per cent. more blows under the drop test than the rough-turned axles, all other conditions being the same.

Other tests made at our works by the inspector of a prominent railroad, showed that a smooth-forged steel axle with 5½-inch x 10-inch journal and 5⅞-inch diameter at the center, successfully withstood 3⅞ times as many blows as a rough-turned axle of same dimensions, both being from the same heat of steel, and both having had the same treatment, the only difference being that one was smooth-forged and the other rough-turned.

From these tests it appears that the smooth-forged axles are stronger than the rough-turned, one of the reasons therefor being that, in this rough-turning, the skin, which is the best part of the material, is removed, whereas in the smooth-forged axles this portion is retained.

SUPERIOR WEARING QUALITIES OF STEEL AXLES.

A series of wearing tests were made as described below, the method used being such as to obtain a fair comparison between steel and iron car axles, with special reference to the wear of the journals.

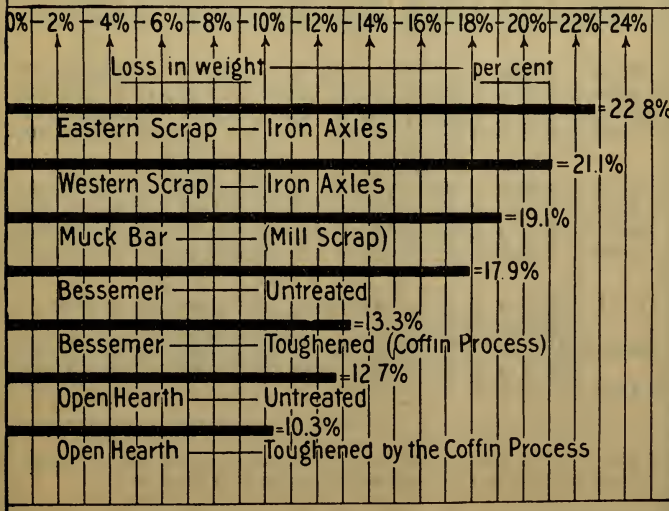
These tests were made on small 1-inch cubes cut from the wheel-seat portions of the axles and near the surface, the wearing face of the cubes being the portions adjacent to the outer surfaces of the axles. The cubes were all planed and finished accurately to 1-inch dimensions, and carefully weighed before and after testing.

The tests were made on a Riehlé abrasion testing-machine, on a hard, smooth steel disk, about 12 inches in diameter, which revolves in a horizontal plane at the rate of about 60 revolutions per minute. The cubes are held in a frame and rest on this disk, the pressure being obtained by a weighted lever above. A cone motion moves the cube and frame in and out over the disk, to which is attached a revolution-counter. The tests were all made on the same disk, and under a pressure of 50 pounds per square inch. The number of revolutions in all cases was 200,000, taking about eight days' time. Two sets of tests were made on each cube and gave practically the same results.

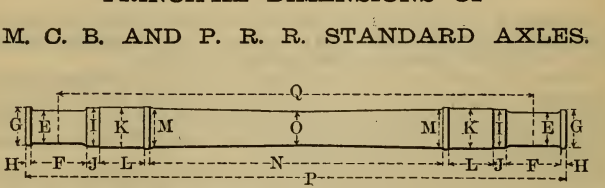
A graphical representation of the results of this series is given clearly in the diagram below, from which the superiority of steel for this purpose is plainly evident.

COMPARATIVE WEAR

Loss in per cent; 8 days run, 200,000 revolutions
Riehlé abrasion testing machine

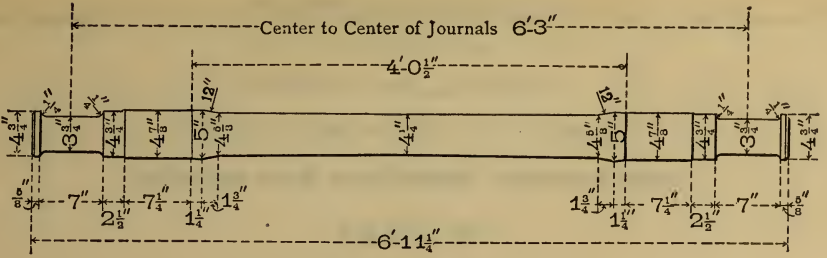


PRINCIPAL DIMENSIONS OF M. C. B. AND P. R. R. STANDARD AXLES.



NOTATION.	MARK.	Size of Journal. Diameter.	Size of Journal. Length.	Diameter of Collar.	Length of Collar.	Diameter of Dust Guard Seat.	Length of Dust Guard Seat.	Diameter of Wheel Seat.	Length of Wheel Seat.	Diameter at End of Taper.	Distance between Shoulders.	Diameter at Center.	Length over All.	Center to Center of Journals.	Average Maximum Weight.
		DIMENSIONS IN INCHES.													Pounds.
		E	F	G	H	I	J	K	L	M	N	O	P	Q	
M. C. B. Axles Standard of 1900.	A	3¾	7	4¾	5/8	4¾	2½	4⅞	7¼	4 5/8	46	4¼	83¼	75	400
	B	4¼	8	5¼	5/8	5¼	2	5⅝	7¼	5 3/8	48½	4⅝	84¼	75	505
	C	5	9	6¼	3/4	6¼	2	6⅝	7¼	6 1/4	47	5⅝	86½	76	680
	D	5½	10	6⅝	3/4	6⅝	2	6⅝	7¼	6 11/16	46	5⅞	88½	77	815
M. C. B. Axles Standard of 1901.	A	3¾	7	4¾	5/8	4¾	2½	5⅛	7¼	5 1/8	47	4¼	83¼	75	425
	B	4¼	8	5¼	5/8	5¼	2	5⅝	7¼	5 3/8	47	4¾	84¼	75	535
	C	5	9	6¼	3/4	6¼	2	6½	7¼	6 1/4	47	5⅝	86½	76	700
	D	5½	10	6⅝	3/4	6⅝	2	7	7¼	7	46	5⅞	88½	77	830
M. C. B. Axles Standard of 1902.	A	3¾	7	4¾	5/8	4¾	2½	5⅛	7¼	4 7/8	46	4¼	83¼	75	410
	B	4¼	8	5¼	5/8	5¼	2	5⅝	7¼	5 7/16	46	4¾	84¼	75	520
	C	5	9	6¼	3/4	6⅝	2	6¼	7¼	6 3/16	46	5⅝	86½	76	685
	D	5½	10	6⅝	3/4	6⅝	2	7	7¼	6 3/4	46	5⅞	88½	77	820
P. R. R. Standard Axles.	2B	3¾	7	4⅝	5/8	4⅝	2⅜	5⅜	7¼	5 1/8	46	4 7/16	83	74¾	440
	4B	4¼	8	5¼	5/8	5¼	2	5⅝	7¼	5 3/8	46	4¾	84¼	75	519
	4A	4¼	8	5½	5/8	5½	2¾	5⅝	7¼	5 3/8	46	4¾	86	76¾	535
	6A	5	9	6½	3/4	6½	2	6½	7¼	6 1/8	46	5⅝	86½	76	680
	7	5½	10	6⅝	3/4	6⅝	2	7	7¼	6 11/16	46	5⅞	88½	77	820

NOTE.—Tables show finished sizes. Rough-turned sizes are about 1/8″ larger. Weights stated are for axles rough-turned on journals and wheel seats.



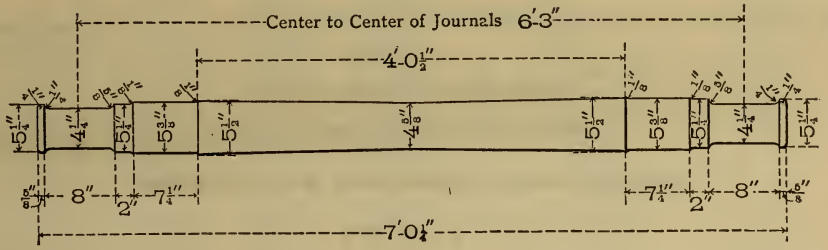
AXLE A.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1900 designed to carry 15,000 lbs.

Average Maximum Weight 400 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.



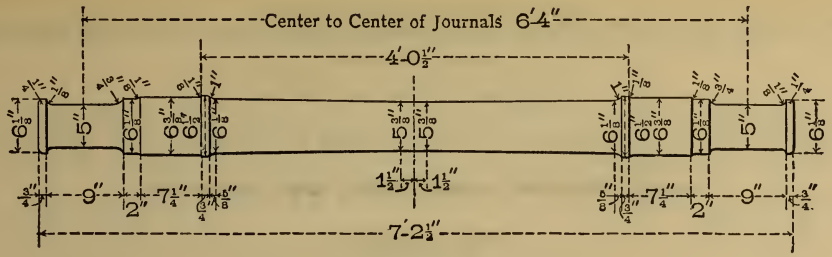
AXLE B.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1900 designed to carry 22,000 lbs.

Average Maximum Weight 505 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.



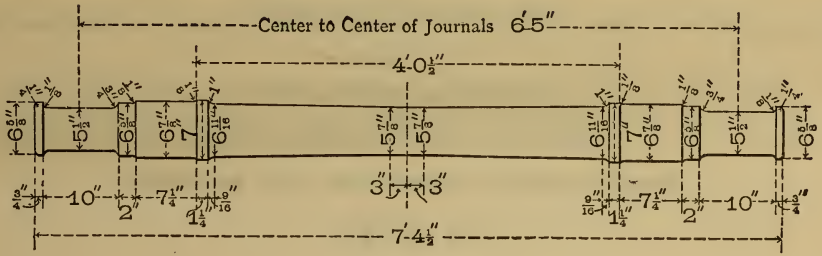
AXLE C.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1900 designed to carry 31,000 lbs.

Average Maximum Weight 680 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.



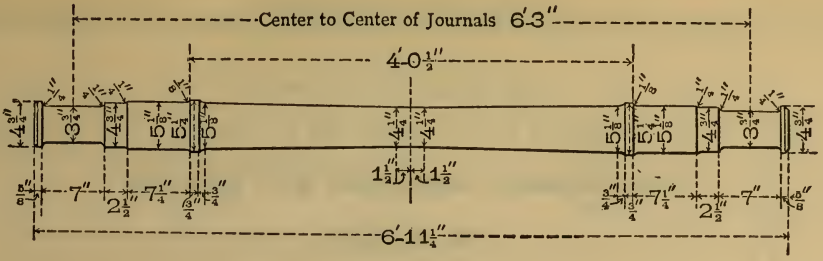
AXLE D.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1900 designed to carry 38,000 lbs.

Average Maximum Weight 815 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.



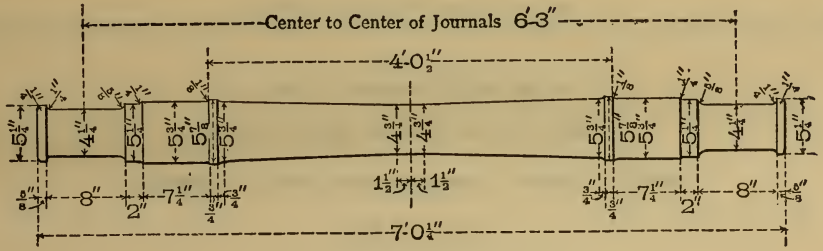
AXLE A.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1901 designed to carry 15,000 lbs.

Average Maximum Weight 425 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.



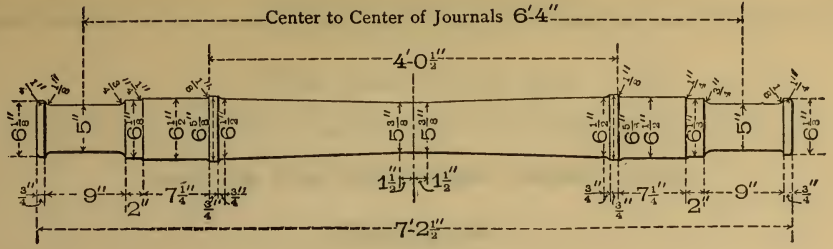
AXLE B.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1901 designed to carry 22,000 lbs.

Average Maximum Weight 535 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.



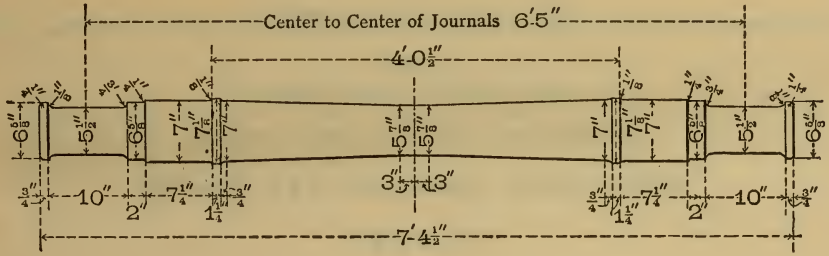
AXLE C.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1901 designed to carry 31,000 lbs.

Average Maximum Weight 700 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.



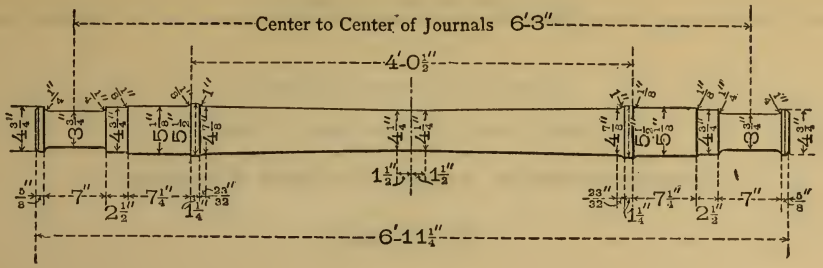
AXLE D.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1901 designed to carry 38,000 lbs.

Average Maximum Weight 830 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛" larger. Weight stated is for axle rough-turned on journals and wheel seats.



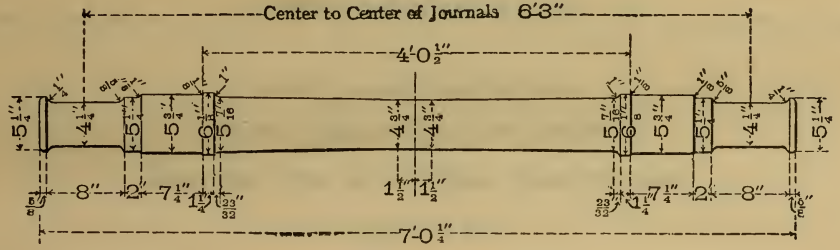
AXLE A.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1902 designed to carry 15,000 lbs.

Average Maximum Weight 410 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛" larger. Weight stated is for axle rough-turned on journals and wheel seats.



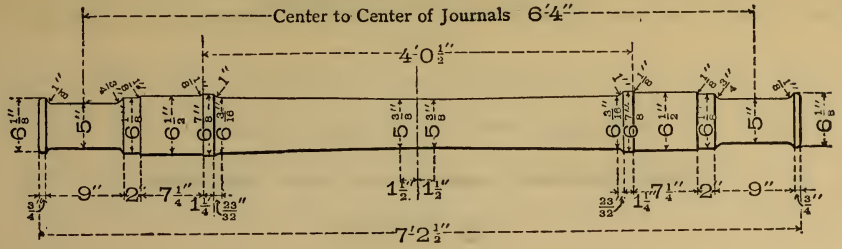
AXLE B.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1902 designed to carry 22,000 lbs.

Average Maximum Weight 520 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.



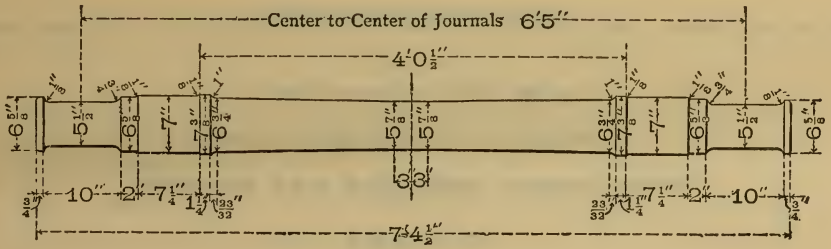
AXLE C.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1902 designed to carry 31,000 lbs.

Average Maximum Weight 685 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.



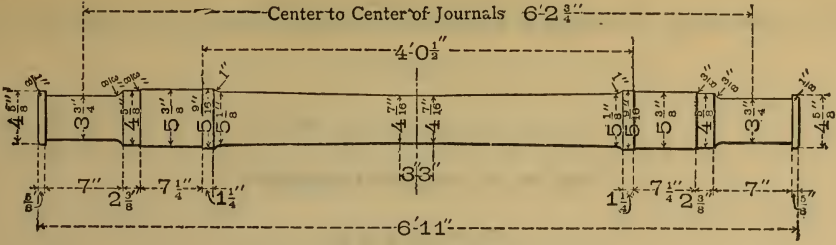
AXLE D.

MASTER CAR BUILDERS' ASSOCIATION.

Standard of 1902 designed to carry 33,000 lbs.

Average Maximum Weight 820 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.

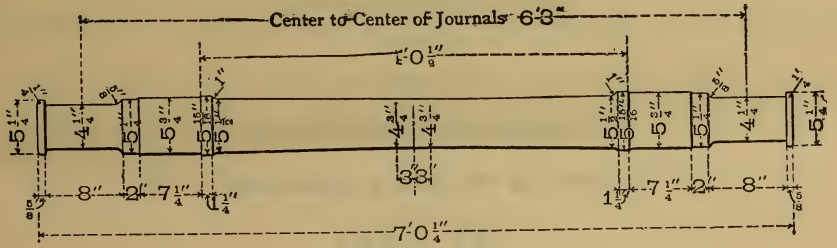


AXLE 2B.

PENNSYLVANIA R. R. CO.

Average Maximum Weight 440 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about ⅛″ larger. Weight stated is for axle rough-turned on journals and wheel seats.

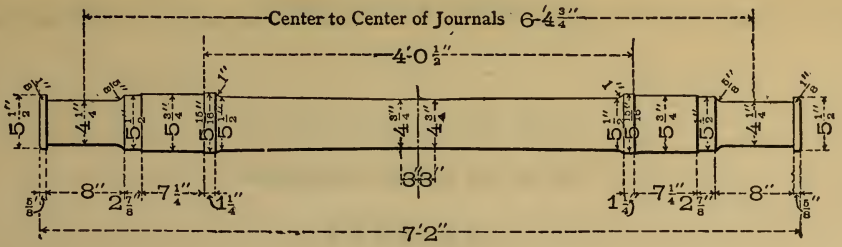


AXLE 4B.

PENNSYLVANIA R. R. CO.

Average Maximum Weight 519 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.

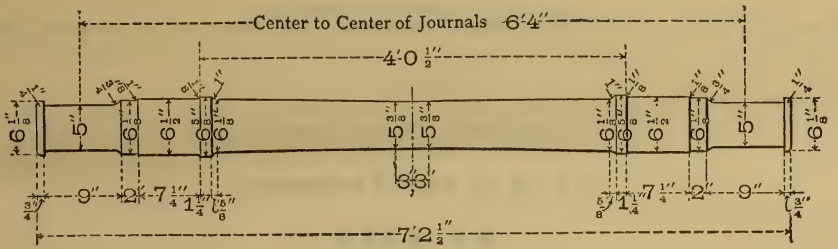


AXLE 4A.

PENNSYLVANIA R. R. CO.

Average Maximum Weight 535 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.

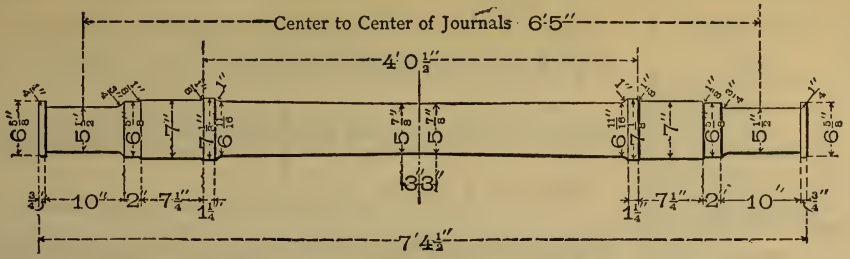


AXLE 6A.

PENNSYLVANIA R. R. CO.

Average Maximum Weight 680 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.



AXLE 7:

PENNSYLVANIA R. R. CO.

Average Maximum Weight 820 lbs.

NOTE.—Dimensions are for finished sizes. Rough-turned sizes are about 1/8" larger. Weight stated is for axle rough-turned on journals and wheel seats.

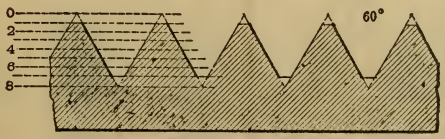
DIMENSIONS OF BOLTS AND NUTS.

Franklin Institute Standard.

Bolts and Threads.						Rough Nuts and Heads.				
Diameter of Bolt.	Threads per Inch.	Diameter at Root of Thread.	Width of Flat.	Area of Bolt Body.	Area of Bolt at Root of Thread.	Short Diameter of Square and Hexagon.	Long Diameter of Square.	Long Diameter of Hexagon.	Thickness of Nuts.	Thickness of Heads.
Ins.	No.	Ins.	Ins.	Sq. Ins.	Sq. Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1/4	20	.185	.0062	.049	.027	1/2	.707	.577	1/4	1/4
5/16	18	.240	.0070	.077	.045	19/32	.840	.686	5/16	1 9/16
3/8	16	.294	.0078	.110	.068	11/16	.972	.794	1/3	1/3
7/16	14	.344	.0089	.150	.093	25/32	1.105	.902	7/16	2 5/6
1/2	13	.400	.0096	.196	.126	7/8	1.238	1.010	1/2	1/6
9/16	12	.454	.0104	.249	.162	31/32	1.370	1.119	9/16	3 1/6
5/8	11	.507	.0113	.307	.202	1 1/16	1.503	1.227	1/3	1/2
3/4	10	.620	.0125	.442	.302	1 1/4	1.768	1.443	5/8	3/4
7/8	9	.731	.0140	.601	.420	1 7/16	2.033	1.660	3/4	2/3
1	8	.837	.0156	.785	.550	1 5/8	2.298	1.876	1	1 3/2
1 1/8	7	.940	.0180	.994	.694	1 13/16	2.563	2.093	1 1/8	1 1/6
1 1/4	7	1.065	.0180	1.227	.893	2	2.829	2.309	1 1/4	2/3
1 3/8	6	1.160	.0210	1.485	1.057	2 3/16	3.094	2.526	1 3/8	1
1 1/2	6	1.284	.0210	1.767	1.295	2 3/8	3.359	2.742	1 1/2	1 3/2
1 5/8	5 1/2	1.389	.0227	2.074	1.515	2 9/16	3.624	2.959	1 5/8	1 3/16
1 3/4	5	1.490	.0250	2.405	1.744	2 3/4	3.889	3.175	1 3/4	1 9/32
1 7/8	5	1.615	.0250	2.761	2.048	2 15/16	4.154	3.392	1 7/8	1 5/16
2	4 1/2	1.712	.0280	3.142	2.302	3 1/8	4.420	3.608	2	1 9/16
2 1/4	4 1/2	1.962	.0280	3.976	3.023	3 1/2	4.950	4.042	2 1/4	1 3/4
2 1/2	4	2.175	.0310	4.909	3.715	3 7/8	5.480	4.475	2 1/2	1 15/16
2 3/4	4	2.425	.0310	5.940	4.619	4 1/4	6.011	4.908	2 3/4	2 1/8
3	3 1/2	2.629	.0357	7.069	5.428	4 5/8	6.541	5.341	3	2 5/16
3 1/4	3 1/2	2.879	.0357	8.296	6.510	5	7.071	5.774	3 1/2	2 1/2
3 1/2	3 1/4	3.100	.0384	9.621	7.548	5 3/8	7.602	6.207	3 1/2	2 11/16
3 3/4	3	3.317	.0410	11.045	8.641	5 3/4	8.132	6.640	3 3/4	2 7/8
4	3	3.567	.0410	12.566	9.993	6 1/8	8.662	7.073	4	3 1/16
4 1/4	2 7/8	3.798	.0435	14.186	11.329	6 1/2	9.193	7.506	4 1/4	3 1/4
4 1/2	2 3/4	4.028	.0460	15.904	12.743	6 7/8	9.723	7.939	4 1/2	3 7/16
4 3/4	2 5/8	4.255	.0480	17.721	14.220	7 1/4	10.253	8.372	4 3/4	3 5/8
5	2 1/2	4.480	.0500	19.635	15.763	7 5/8	10.784	8.805	5	3 13/16
5 1/4	2 1/2	4.730	.0500	21.648	17.572	8	11.314	9.238	5 1/4	4
5 1/2	2 3/8	4.953	.0526	23.758	19.267	8 3/8	11.844	9.671	5 1/2	4 3/16
5 3/4	2 1/4	5.203	.0526	25.967	21.262	8 3/4	12.375	10.104	5 3/4	4 3/8
6	2 1/4	5.423	.0555	28.274	23.098	9 1/8	12.905	10.537	6	4 9/16

RULES FOR PROPORTIONS OF BOLTS AND NUTS.

FRANKLIN INSTITUTE STANDARD.



The dimensions of nuts and bolts are determined by the following rules, which apply to both square and hexagon.

Short diameter of rough nut $= 1\frac{1}{2} \times$ diameter of bolt $+ \frac{1}{8}$ in.

Short diameter of finished nut $= 1\frac{1}{2} \times$ diameter of bolt $+ \frac{1}{16}$ in.

Thickness of rough nut = diameter of bolt.

Thickness of finished nut = diameter of bolt $- \frac{1}{16}$ in.

Short diameter of rough head $= 1\frac{1}{2} \times$ diameter of bolt $+ \frac{1}{8}$ in.

Short diameter of finished head $= 1\frac{1}{2} \times$ diameter of bolt $+ \frac{1}{16}$ in.

Thickness of rough head $= \frac{1}{2}$ of short diameter of head.

Thickness of finished head = diameter of bolt $- \frac{1}{16}$ in.

In 1864, a committee of the Franklin Institute recommended the above system of screw threads and bolts which was devised by Mr. William Sellers, of Philadelphia. This system as far as it relates to screw threads is generally used in the United States, but the proportions of bolt heads and nuts are not adhered to because the sizes of bar required to make the nuts are special and extra work is necessary to make the bolt heads.

WEIGHTS OF SQUARE AND ROUND BARS PER RUNNING INCH.

One cubic inch of steel weighs 0.2833 lb.

Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.	Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.
			2	1.13	.89
1/16	. .	. .	1/16	1.21	.95
1/8	. .	. .	1/8	1.28	1.01
3/16	.01	. .	3/16	1.36	1.07
1/4	.02	.01	1/4	1.43	1.13
5/16	.03	.02	5/16	1.52	1.19
3/8	.04	.03	3/8	1.60	1.26
7/16	.05	.04	7/16	1.68	1.32
1/2	.07	.06	1/2	1.77	1.39
9/16	.09	.07	9/16	1.86	1.46
5/8	.11	.09	5/8	1.95	1.54
11/16	.13	.11	11/16	2.05	1.61
3/4	.16	.13	3/4	2.14	1.69
13/16	.19	.15	13/16	2.24	1.76
7/8	.22	.17	7/8	2.34	1.84
15/16	.25	.20	15/16	2.44	1.92
1	.28	.22	3	2.55	2.01
1/16	.32	.25	1/16	2.66	2.09
1/8	.36	.28	1/8	2.77	2.18
3/16	.40	.31	3/16	2.88	2.26
1/4	.44	.35	1/4	2.99	2.35
5/16	.49	.38	5/16	3.11	2.44
3/8	.54	.42	3/8	3.23	2.53
7/16	.58	.46	7/16	3.35	2.63
1/2	.64	.50	1/2	3.47	2.73
9/16	.69	.54	9/16	3.60	2.82
5/8	.75	.59	5/8	3.72	2.92
11/16	.81	.63	11/16	3.85	3.03
3/4	.87	.68	3/4	3.98	3.13
13/16	.94	.73	13/16	4.12	3.23
7/8	1.00	.78	7/8	4.25	3.34
15/16	1.06	.84	15/16	4.39	3.45

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.	Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.
4	4.53	3.57	6	10.20	8.01
1/16	4.68	3.67	1/16	10.41	8.18
1/8	4.82	3.79	1/8	10.63	8.35
3/16	4.97	3.90	3/16	10.85	8.52
1/4	5.12	4.02	1/4	11.07	8.69
5/16	5.27	4.14	5/16	11.29	8.87
3/8	5.42	4.26	3/8	11.51	9.04
7/16	5.58	4.38	7/16	11.74	9.22
1/2	5.74	4.51	1/2	11.97	9.40
9/16	5.90	4.63	9/16	12.20	9.58
5/8	6.06	4.76	5/8	12.43	9.77
11/16	6.23	4.89	11/16	12.67	9.95
3/4	6.39	5.02	3/4	12.91	10.14
13/16	6.56	5.15	13/16	13.15	10.33
7/8	6.73	5.29	7/8	13.39	10.52
15/16	6.91	5.42	15/16	13.64	10.71
5	7.08	5.56	7	13.88	10.90
1/16	7.26	5.70	1/16	14.13	11.10
1/8	7.44	5.84	1/8	14.38	11.30
3/16	7.62	5.99	3/16	14.64	11.50
1/4	7.81	6.13	1/4	14.89	11.70
5/16	8.00	6.28	5/16	15.15	11.90
3/8	8.19	6.43	3/8	15.41	12.10
7/16	8.38	6.58	7/16	15.67	12.31
1/2	8.57	6.73	1/2	15.94	12.52
9/16	8.77	6.88	9/16	16.20	12.73
5/8	8.96	7.04	5/8	16.47	12.94
11/16	9.16	7.20	11/16	16.74	13.15
3/4	9.37	7.36	3/4	17.02	13.36
13/16	9.57	7.52	13/16	17.29	13.58
7/8	9.78	7.68	7/8	17.57	13.80
15/16	9.99	7.84	15/16	17.85	14.02

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.	Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.
8	18.11	14.24	10	28.33	22.25
1/16	18.42	14.46	1/16	28.69	22.53
1/8	18.70	14.69	1/8	29.04	22.81
3/16	18.99	14.92	3/16	29.41	23.09
1/4	19.28	15.14	1/4	29.77	23.38
5/16	19.58	15.38	5/16	30.13	23.66
3/8	19.87	15.61	3/8	30.50	23.95
7/16	20.17	15.84	7/16	30.87	24.24
1/2	20.47	16.08	1/2	31.24	24.53
9/16	20.77	16.31	9/16	31.61	24.82
5/8	21.08	16.55	5/8	31.98	25.12
11/16	21.38	16.79	11/16	32.36	25.42
3/4	21.69	17.04	3/4	32.74	25.71
13/16	22.00	17.28	13/16	33.12	26.01
7/8	22.31	17.53	7/8	33.51	26.32
15/16	22.63	17.77	15/16	33.89	26.62
9	22.95	18.02	11	34.28	26.92
1/16	23.27	18.27	1/16	34.67	27.23
1/8	23.59	18.53	1/8	35.06	27.54
3/16	23.91	18.78	3/16	35.46	27.85
1/4	24.24	19.04	1/4	35.86	28.16
5/16	24.57	19.30	5/16	36.26	28.48
3/8	24.90	19.56	3/8	36.66	28.79
7/16	25.23	19.82	7/16	37.06	29.11
1/2	25.57	20.08	1/2	37.47	29.43
9/16	25.91	20.35	9/16	37.88	29.75
5/8	26.25	20.61	5/8	38.29	30.07
11/16	26.59	20.88	11/16	38.70	30.39
3/4	26.93	21.15	3/4	39.12	30.72
13/16	27.28	21.42	13/16	39.53	31.04
7/8	27.63	21.70	7/8	39.95	31.38
15/16	27.98	21.97	15/16	40.37	31.71

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.	Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.
12	40.80	32.04	16	72.53	56.96
1/8	41.65	32.71	1/8	73.67	57.86
1/4	42.52	33.39	1/4	74.81	58.76
3/8	43.39	34.08	3/8	75.97	59.66
1/2	44.27	34.77	1/2	77.13	60.58
5/8	45.16	35.47	5/8	78.31	61.50
3/4	46.06	36.17	3/4	79.49	62.43
7/8	46.96	36.88	7/8	80.68	63.36
13	47.88	37.60	17	81.88	64.30
1/8	48.81	38.33	1/8	83.09	65.25
1/4	49.74	39.06	1/4	84.30	66.21
3/8	50.68	39.80	3/8	85.53	67.17
1/2	51.63	40.55	1/2	86.77	68.14
5/8	52.59	41.31	5/8	88.01	69.12
3/4	53.56	42.07	3/4	89.26	70.10
7/8	54.54	42.84	7/8	90.52	71.09
14	55.53	43.62	18	91.79	72.09
1/8	56.53	44.39	1/8	93.07	73.10
1/4	57.53	45.18	1/4	94.36	74.11
3/8	58.54	45.98	3/8	95.66	75.13
1/2	59.57	46.78	1/2	96.96	76.15
5/8	60.60	47.59	5/8	98.28	77.19
3/4	61.64	48.41	3/4	99.60	78.22
7/8	62.69	49.23	7/8	100.94	79.27
15	63.75	50.06	19	102.28	80.32
1/8	64.81	50.90	1/8	103.63	81.39
1/4	65.89	51.75	1/4	104.99	82.45
3/8	66.97	52.60	3/8	106.35	83.53
1/2	68.07	53.46	1/2	107.73	84.61
5/8	69.17	54.32	5/8	109.12	85.70
3/4	70.28	55.20	3/4	110.51	86.79
7/8	71.40	56.08	7/8	111.91	87.89

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.	Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.
20	113.33	89.00	24	163.19	128.16
1/8	114.75	90.12	1/8	164.89	129.50
1/4	116.18	91.24	1/4	166.61	130.85
3/8	117.62	92.37	3/8	168.33	132.20
1/2	119.06	93.51	1/2	170.06	133.57
5/8	120.52	94.65	5/8	171.80	134.93
3/4	121.98	95.80	3/4	173.55	136.30
7/8	123.46	96.96	7/8	175.31	137.68
21	124.94	98.13	25	177.07	139.07
1/8	126.43	99.30	1/8	178.85	140.46
1/4	127.93	100.48	1/4	180.63	141.86
3/8	129.44	101.66	3/8	182.42	143.27
1/2	130.96	102.85	1/2	184.23	144.68
5/8	132.49	104.05	5/8	186.04	146.11
3/4	134.03	105.26	3/4	187.86	147.54
7/8	135.57	106.47	7/8	189.68	148.97
22	137.12	107.69	26	191.52	150.41
1/8	138.69	108.92	1/8	193.37	151.86
1/4	140.26	110.15	1/4	195.22	153.32
3/8	141.84	111.40	3/8	197.09	154.78
1/2	143.43	112.64	1/2	198.96	156.25
5/8	145.03	113.90	5/8	200.84	157.73
3/4	146.63	115.16	3/4	202.73	159.22
7/8	148.25	116.43	7/8	204.63	160.71
23	149.88	117.71	27	206.54	162.21
1/8	151.51	118.99	1/8	208.45	163.71
1/4	153.15	120.28	1/4	210.38	165.22
3/8	154.81	121.58	3/8	212.31	166.74
1/2	156.46	122.88	1/2	214.26	168.27
5/8	158.13	124.19	5/8	216.21	169.80
3/4	159.81	125.51	3/4	218.17	171.34
7/8	161.49	126.83	7/8	220.14	172.89

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.	Thickness or Diameter in Inches.	Weight of □ Bar.	Weight of ○ Bar.
28	222.12	174.44	32	290.11	227.85
1/8	224.11	176.01	1/8	292.39	229.63
1/4	226.10	177.57	1/4	294.67	231.42
3/8	228.11	179.15	3/8	296.95	233.22
1/2	230.12	180.73	1/2	299.25	235.02
5/8	232.15	182.32	5/8	301.56	236.83
3/4	234.18	183.91	3/4	303.87	238.65
7/8	236.22	185.52	7/8	306.20	240.48
29	238.27	187.13	33	308.53	242.31
1/8	240.33	188.74	1/8	310.87	244.15
1/4	242.39	190.37	1/4	313.22	245.99
3/8	244.47	192.00	3/8	315.58	247.85
1/2	246.56	193.64	1/2	317.95	249.71
5/8	248.65	195.28	5/8	320.33	251.57
3/4	250.75	196.93	3/4	322.71	253.45
7/8	252.86	198.59	7/8	325.11	255.33
30	254.98	200.25	34	327.51	257.22
1/8	257.11	201.93	1/8	329.93	259.11
1/4	259.25	203.61	1/4	332.35	261.01
3/8	261.40	205.29	3/8	334.78	262.92
1/2	263.55	206.99	1/2	337.22	264.84
5/8	265.72	208.69	5/8	339.66	266.76
3/4	267.89	210.39	3/4	342.12	268.69
7/8	270.07	212.11	7/8	344.59	270.63
31	272.27	213.83	35	347.06	272.57
1/8	274.47	215.56	1/8	349.54	274.52
1/4	276.68	217.29	1/4	352.04	276.48
3/8	278.89	219.03	3/8	354.54	278.44
1/2	281.12	220.78	1/2	357.05	280.41
5/8	283.36	222.54	5/8	359.57	282.39
3/4	285.60	224.30	3/4	362.09	284.38
7/8	287.85	226.07	7/8	364.63	286.37

STANDARD DECIMAL GAUGE.

Standard Decimal Gauge in Inches.	Thickness in Fractions of an Inch.	Approximate Thickness in Millimetres.	Weight per Square Foot in Pounds, Avoirdupois.	
			IRON. Basis—480 Pounds per Cubic Foot.	STEEL. Basis—489.6 Pounds per Cubic Foot.
.002	1-500	.05080010	.08	.0816
.004	1-250	.10160020	.16	.1632
.006	3-500	.15240030	.24	.2448
.008	1-125	.20320041	.32	.3264
.010	1-100	.25400051	.40	.4080
.012	3-250	.30480061	.48	.4896
.014	7-500	.35560071	.56	.5712
.016	2-125($\frac{1}{64}$+)	.40640081	.64	.6528
.018	9-500	.45720091	.72	.7344
.020	1-50	.50800102	.80	.8160
.022	11-500	.55880112	.88	.8976
.025	1-40	.63500127	1.00	1.0200
.028	7-250	.71120142	1.12	1.1424
.032	4-125($\frac{1}{32}$+)	.81280163	1.28	1.3056
.036	9-250	.91440183	1.44	1.4688
.040	1-25	1.01600203	1.60	1.6320
.045	9-200	1.14300229	1.80	1.8360
.050	1-20	1.27000254	2.00	2.0400
.055	11-200	1.39700280	2.20	2.2440
.060	3-50 ($\frac{1}{16}$—)	1.52400305	2.40	2.4480
.065	13-200	1.65100330	2.60	2.6520
.070	7-100	1.77800356	2.80	2.8560
.075	3-40	1.90500381	3.00	3.0600
.080	2-25	2.03200406	3.20	3.2640
.085	17-200	2.15900432	3.40	3.4680
.090	9-100	2.28600457	3.60	3.6720
.095	19-200	2.41300483	3.80	3.8760
.100	1-10	2.54000508	4.00	4.0800
.110	11-100	2.79400559	4.40	4.4880
.125	1-8	3.17500630	5.00	5.1000
.135	27-200	3.42900686	5.40	5.5080
.150	3-20	3.81000762	6.00	6.1200
.165	33-200	4.19100838	6.60	6.7320
.180	9-50	4.57200914	7.20	7.3440
.200	1-5	5.08001016	8.00	8.1600
.220	11-50	5.58801118	8.80	8.9760
.240	6-25	6.09601219	9.60	9.7920
.250	1-4	6.35001270	10.00	10.2000

The Standard Decimal Gauge has been recently adopted by the Association of American Steel Manufacturers, the American Railway Master Mechanics' Association and by about seventy-two of the principal railroads of the United States, Canada and Mexico. The decimal system of gauging was recommended by the American Institute of Mining Engineers in 1877 and by the American Society of Mechanical Engineers in 1895.

WIRE AND SHEET METAL GAUGES.

In Decimals of an Inch.

Number of Gauge.	Birmingham or Stubs Iron Wire Gauge.	American or Brown & Sharpe Wire Gauge.	United States Standard Gauge for Sheet and Plate Iron and Steel.	Washburn & Moen Manufacturing Co. and John A. Roebling's Sons Co. Wire Gauge.	Trenton Iron Co. Wire Gauge.	American Screw Co. Screw Wire Gauge.	British Imperial or English Legal Standard Wire Gauge.
0000000	. . .	. . . . .	.5	. . . . .	. . . .	. . . .	.500
000000	. . .	. . . . .	.46875	.4600	. . . .	. . . .	.464
00000	. . .	. . . . .	.4375	.4300	.450	. . . .	.432
0000	.454	.460000	.40625	.3938	.400	. . . .	.400
000	.425	.409642	.375	.3625	.360	.0315	.372
00	.380	.364796	.34375	.3310	.330	.0447	.348
0	.340	.324861	.3125	.3065	.305	.0578	.324
1	.300	.289297	.28125	.2830	.285	.0710	.300
2	.284	.257627	.265625	.2625	.265	.0842	.276
3	.259	.229423	.25	.2437	.245	.0973	.252
4	.238	.204307	.234375	.2253	.225	.1105	.232
5	.220	.181940	.21875	.2070	.205	.1236	.212
6	.203	.162023	.203125	.1920	.190	.1368	.192
7	.180	.144285	.1875	.1770	.175	.1500	.176
8	.165	.128490	.171875	.1620	.160	.1631	.160
9	.148	.114423	.15625	.1483	.145	.1763	.144
10	.134	.101897	.140625	.1350	.130	.1894	.128
11	.120	.090742	.125	.1205	.1175	.2026	.116
12	.109	.080808	.109375	.1055	.105	.2158	.104
13	.095	.071962	.09375	.0915	.0925	.2289	.092
14	.083	.064084	.078125	.0800	.0806	.2421	.080
15	.072	.057068	.0703125	.0720	.070	.2552	.072
16	.065	.050821	.0625	.0625	.061	.2684	.064
17	.058	.045257	.05625	.0540	.0525	.2816	.056
18	.049	.040303	.05	.0475	.045	.2947	.048
19	.042	.035890	.04375	.0410	.040	.3079	.040
20	.035	.031961	.0375	.0348	.035	.3210	.036
21	.032	.028462	.034375	.03175	.031	.3342	.032
22	.028	.025346	.03125	.0286	.028	.3474	.028
23	.025	.022572	.028125	.0258	.025	.3605	.024
24	.022	.020101	.025	.0230	.0225	.3737	.022
25	.020	.017900	.021875	.0204	.020	.3868	.020
26	.018	.015941	.01875	.0181	.018	.4000	.018
27	.016	.014195	.0171875	.0173	.017	.4132	.0164
28	.014	.012641	.015625	.0162	.016	.4263	.0148
29	.013	.011257	.0140625	.0150	.015	.4395	.0136
30	.012	.010025	.0125	.0140	.014	.4526	.0124
31	.010	.008928	.0109375	.0132	.013	.4658	.0116
32	.009	.007950	.01015625	.0128	.012	.4790	.0108
33	.008	.007080	.009375	.0118	.011	.4921	.0100
34	.007	.006305	.00859375	.0104	.010	.5053	.0092
35	.005	.005615	.0078125	.0095	.0095	.5184	.0084
36	.004	.005000	.00703125	.0090	.009	.5316	.0076
37	. . .	.004453	.006640625	.0085	.0085	.5448	.0068
38	. . .	.003965	.00625	.0080	.008	.5579	.0060
39	. . .	.003531	. . . . .	.0075	.0075	.5711	.0052
40	. . .	.003144	. . . . .	.0070	.007	.5842	.0048

The United States Standard Gauge was legalized by Act of Congress March 3, 1893, as a standard gauge for sheet and plate iron and steel and is used by the Custom House Department and by about forty-five sheet and tin-plate manufacturers.

WEIGHTS OF SHEETS AND PLATES OF STEEL, WROUGHT IRON, COPPER AND BRASS.

AMERICAN OR BROWNE & SHARPE GAUGE.

No. of Gauge.	Thickness in Inches.	Weight per Square Foot.			
		Steel.	Iron.	Copper.	Brass.
0000	.460000	18.7680	18.4000	20.8380	19.6880
000	.409642	16.7134	16.3857	18.5568	17.5327
00	.364796	14.8837	14.5918	16.5253	15.6133
0	.324861	13.2543	12.9944	14.7162	13.9041
1	.289297	11.8033	11.5719	13.1052	12.3819
2	.257627	10.5112	10.3051	11.6705	11.0264
3	.229423	9.3605	9.1769	10.3929	9.8193
4	.204307	8.3357	8.1723	9.2551	8.7443
5	.181940	7.4232	7.2776	8.2419	7.7870
6	.162023	6.6105	6.4809	7.3396	6.9346
7	.144285	5.8868	5.7714	6.5361	6.1754
8	.128490	5.2424	5.1396	5.8206	5.4994
9	.114423	4.6685	4.5769	5.1834	4.8973
10	.101897	4.1574	4.0759	4.6159	4.3612
11	.090742	3.7023	3.6297	4.1106	3.8838
12	.080808	3.2970	3.2323	3.6606	3.4586
13	.071962	2.9360	2.8785	3.2599	3.0800
14	.064084	2.6146	2.5634	2.9030	2.7428
15	.057068	2.3284	2.2827	2.5852	2.4425
16	.050821	2.0735	2.0328	2.3022	2.1751
17	.045257	1.8465	1.8103	2.0501	1.9370
18	.040303	1.6444	1.6121	1.8257	1.7250
19	.035890	1.4643	1.4356	1.6258	1.5361
20	.031961	1.3040	1.2784	1.4478	1.3679
21	.028462	1.1612	1.1385	1.2893	1.2182
22	.025346	1.0341	1.0138	1.1482	1.0848
23	.022572	.92094	.90288	1.0225	.96608
24	.020101	.82012	.80404	.91058	.86032
25	.017900	.73032	.71600	.81087	.76612
26	.015941	.65039	.63764	.72213	.68227
27	.014195	.57916	.56780	.64303	.60755
28	.012641	.51575	.50564	.57264	.54103
29	.011257	.45929	.45028	.50994	.48180
30	.010025	.40902	.40100	.45413	.42907
31	.008928	.36426	.35712	.40444	.38212
32	.007950	.32436	.31800	.36014	.34026
33	.007080	.28886	.28320	.32072	.30302
34	.006305	.25724	.25220	.28562	.26985
35	.005615	.22909	.22460	.25436	.24032
36	.005000	.20400	.20000	.22650	.21400
37	.004453	.18168	.17812	.20172	.19059
38	.003965	.16177	.15860	.17961	.16970
39	.003531	.14406	.14124	.15995	.15113
40	.003144	12828	.12576	.14242	.13456

For weights of steel plates $\frac{1}{16}$" and over in thickness, see "Weights of Flat Rolled Steel Bars," pages 48 to 57.

WEIGHTS OF SHEETS AND PLATES OF STEEL, WROUGHT IRON, COPPER AND BRASS.

BIRMINGHAM GAUGE.

No. of Gauge.	Thickness in Inches.	Weight per Square Foot.			
		Steel.	Iron.	Copper.	Brass.
0000	.454	18.5232	18.16	20.5662	19.4312
000	.425	17.3400	17.00	19.2525	18.1900
00	.380	15.5040	15.20	17.2140	16.2640
0	.340	13.8720	13.60	15.4020	14.5520
1	.300	12.2400	12.00	13.5900	12.8400
2	.284	11.5872	11.36	12.8652	12.1552
3	.259	10.5672	10.36	11.7327	11.0852
4	.238	9.7104	9.52	10.7814	10.1864
5	.220	8.9760	8.80	9.966	9.4160
6	.203	8.2824	8.12	9.1959	8.6884
7	.180	7.3440	7.20	8.1540	7.7040
8	.165	6.7320	6.60	7.4745	7.0620
9	.148	6.0384	5.92	6.7044	6.3344
10	.134	5.4672	5.36	6.0702	5.7352
11	.120	4.8960	4.80	5.4360	5.1360
12	.109	4.4472	4.36	4.9377	4.6652
13	.095	3.8760	3.80	4.3035	4.0660
14	.083	3.3864	3.32	3.7599	3.5524
15	.072	2.9376	2.88	3.2616	3.0816
16	.065	2.6520	2.60	2.9445	2.7820
17	.058	2.3664	2.32	2.6274	2.4824
18	.049	1.9992	1.96	2.2197	2.0972
19	.042	1.7136	1.68	1.9026	1.7976
20	.035	1.4280	1.40	1.5855	1.4980
21	.032	1.3056	1.28	1.4496	1.3696
22	.028	1.1424	1.12	1.2684	1.1984
23	.025	1.0200	1.00	1.1325	1.0700
24	.022	.8976	.88	.9966	.9416
25	.020	.8160	.80	.9060	.8560
26	.018	.7344	.72	.8154	.7704
27	.016	.6528	.64	.7248	.6848
28	.014	.5712	.56	.6342	.5992
29	.013	.5304	.52	.5889	.5564
30	.012	.4896	.48	.5436	.5136
31	.010	.4080	.40	.4530	.4280
32	.009	.3672	.36	.4077	.3852
33	.008	.3264	32	.3624	.3424
34	.007	.2856	.28	.3171	.2996
35	.005	.2040	.20	.2265	.2140
36	.004	.1632	.16	.1812	.1712
Specific Gravities		7.85	7.70	8.72	8.24
Weight of a Cubic Foot ..		489.6	480.0	543.6	513.6
" " " Inch ..		.2833	.2778	.3146	.2972

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

One cubic foot of steel weighs 489.6 pounds.

For thicknesses from $\frac{1}{16}$ inch to $\frac{9}{16}$ inch and widths from $\frac{1}{4}$ inch to $\frac{3}{4}$ inch.

Thickness in Inches.	1/4"	17/64"	9/32"	19/64"	5/16"	21/64"	11/32"	23/64"	3/8"
1/16	.053	.056	.060	.063	.066	.070	.073	.076	.080
5/64	.066	.071	.075	.079	.083	.087	.091	.095	.100
3/32	.080	.085	.090	.095	.100	.105	.110	.115	.120
7/64	.093	.099	.105	.110	.116	.122	.128	.134	.139
1/8	.106	.113	.120	.126	.133	.139	.146	.153	.159
9/64	.120	.127	.134	.142	.149	.157	.164	.172	.179
5/32	.133	.141	.149	.158	.166	.174	.183	.191	.199
11/64	.146	.155	.164	.173	.183	.192	.201	.210	.219
3/16	.159	.169	.179	.189	.199	.209	.219	.229	.239
13/64	.173	.183	.194	.205	.216	.227	.237	.248	.259
7/32	.186	.198	.209	.221	.232	.244	.256	.267	.279
15/64	.199	.212	.224	.237	.249	.261	.274	.286	.299
1/4	.213	.226	.239	.252	.266	.279	.292	.305	.319
17/64	.226	.240	.254	.268	.282	.296	.310	.325	.339
9/32	.239	.254	.269	.284	.299	.314	.329	.344	.359
19/64	.252	.268	.284	.300	.315	.331	.347	.363	.379
5/16	.266	.282	.299	.315	.332	.349	.365	.382	.398
21/64	.279	.296	.314	.331	.349	.366	.383	.401	.418
11/32	.292	.310	.329	.347	.365	.383	.402	.420	.438
23/64	.305	.325	.344	.363	.382	.401	.420	.439	.458
3/8	.319	.339	.359	.379	.398	.418	.438	.458	.478
25/64	.332	.353	.374	.394	.415	.436	.457	.477	.498
13/32	.345	.367	.388	.410	.432	.453	.475	.496	.518
27/64	.359	.381	.403	.426	.448	.471	.493	.515	.538
7/16	.372	.395	.418	.442	.465	.488	.511	.535	.558
29/64	.385	.409	.433	.457	.481	.506	.530	.554	.578
15/32	.398	.423	.448	.473	.498	.523	.548	.573	.598
31/64	.412	.437	.463	.489	.515	.540	.566	.592	.618
1/2	.425	.452	.478	.505	.531	.558	.584	.611	.638
33/64	.438	.466	.493	.520	.548	.575	.603	.630	.657
17/32	.452	.480	.508	.536	.564	.593	.621	.649	.677
35/64	.465	.494	.523	.552	.581	.610	.639	.668	.697
9/16	.478	.508	.538	.567	.598	.628	.657	.687	.717

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	25/64"	13/32"	27/64"	7/16"	29/64"	15/32"	31/64"	1/2"	12"
1/16	.083	.086	.090	.093	.096	.100	.103	.106	2.53
5/64	.104	.108	.112	.116	.120	.125	.129	.133	3.19
3/32	.125	.129	.134	.139	.144	.149	.154	.159	3.83
7/64	.145	.151	.157	.163	.169	.174	.180	.186	4.46
1/8	.166	.173	.179	.186	.193	.199	.206	.212	5.10
9/64	.187	.194	.202	.209	.217	.224	.232	.239	5.74
5/32	.208	.216	.224	.232	.241	.249	.257	.266	6.38
11/64	.228	.237	.247	.256	.265	.274	.283	.292	7.01
3/16	.249	.259	.269	.279	.289	.299	.309	.319	7.65
13/64	.270	.281	.291	.302	.313	.324	.335	.345	8.29
7/32	.291	.302	.314	.325	.337	.349	.360	.372	8.93
15/64	.311	.324	.336	.349	.361	.374	.386	.398	9.56
1/4	.332	.345	.359	.372	.385	.398	.412	.425	10.20
17/64	.353	.367	.381	.395	.409	.423	.437	.452	10.84
9/32	.374	.388	.403	.418	.433	.448	.463	.478	11.48
19/64	.394	.410	.426	.442	.457	.473	.489	.505	12.11
5/16	.415	.432	.448	.465	.481	.498	.515	.531	12.75
21/64	.436	.453	.471	.488	.506	.523	.540	.558	13.39
11/32	.457	.475	.493	.511	.530	.548	.566	.584	14.03
23/64	.477	.496	.515	.535	.554	.573	.592	.611	14.66
3/8	.498	.518	.538	.558	.578	.598	.618	.638	15.30
25/64	.519	.540	.560	.581	.602	.623	.643	.664	15.94
13/32	.540	.561	.583	.604	.626	.647	.669	.691	16.58
27/64	.560	.583	.605	.628	.650	.672	.695	.717	17.21
7/16	.581	.604	.628	.651	.674	.697	.721	.744	17.85
29/64	.602	.626	.650	.674	.698	.722	.746	.770	18.49
15/32	.623	.647	.672	.697	.722	.747	.772	.797	19.13
31/64	.643	.669	.695	.721	.746	.772	.798	.823	19.76
1/2	.664	.691	.717	.744	.770	.797	.823	.850	20.40
33/64	.685	.712	.740	.767	.794	.822	.849	.877	21.04
17/32	.706	.734	.762	.790	.818	.847	.875	.903	21.68
35/64	.726	.755	.784	.813	.843	.872	.901	.930	22.31
9/16	.747	.777	.807	.837	.867	.896	.926	.956	22.95

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	33/64"	17/32"	35/64"	9/16"	37/64"	19/32"	39/64"	5/8"	12"
1/16	.110	.113	.116	.120	.123	.126	.129	.133	2.53
5/64	.137	.141	.145	.149	.154	.158	.162	.166	3.19
3/32	.164	.169	.174	.179	.184	.189	.194	.199	3.83
7/64	.192	.198	.203	.209	.215	.221	.227	.232	4.46
1/8	.219	.226	.232	.239	.246	.252	.259	.266	5.10
9/64	.247	.254	.261	.269	.276	.284	.291	.299	5.74
5/32	.274	.282	.291	.299	.307	.315	.324	.332	6.38
11/64	.301	.310	.320	.329	.338	.347	.356	.365	7.01
3/16	.329	.339	.349	.359	.369	.379	.388	.398	7.65
13/64	.356	.367	.378	.388	.399	.410	.421	.432	8.29
7/32	.383	.395	.407	.418	.430	.442	.453	.465	8.93
15/64	.411	.423	.436	.448	.461	.473	.486	.498	9.56
1/4	.438	.452	.465	.478	.491	.505	.518	.531	10.20
17/64	.466	.480	.494	.508	.522	.536	.550	.564	10.84
9/32	.493	.508	.523	.538	.553	.568	.583	.598	11.48
19/64	.520	.536	.552	.568	.584	.599	.615	.631	12.11
5/16	.548	.564	.581	.598	.614	.631	.647	.664	12.75
21/64	.575	.593	.610	.628	.645	.662	.680	.697	13.39
11/32	.603	.621	.639	.657	.676	.694	.712	.730	14.03
23/64	.630	.649	.668	.687	.706	.725	.745	.764	14.66
3/8	.657	.677	.697	.717	.737	.757	.777	.797	15.30
25/64	.685	.706	.726	.747	.768	.789	.809	.830	15.94
13/32	.712	.734	.755	.777	.799	.820	.842	.863	16.58
27/64	.740	.762	.784	.807	.829	.852	.874	.896	17.21
7/16	.767	.790	.813	.837	.860	.883	.906	.930	17.85
29/64	.794	.818	.843	.867	.891	.915	.939	.963	18.49
15/32	.822	.847	.872	.896	.921	.946	.971	.996	19.13
31/64	.849	.875	.901	.926	.952	.978	1.00	1.03	19.76
1/2	.877	.903	.930	.956	.983	1.01	1.04	1.06	20.40
33/64	.904	.931	.959	.986	1.01	1.04	1.07	1.10	21.04
17/32	.931	.960	.988	1.02	1.04	1.07	1.10	1.13	21.68
35/64	.959	.988	1.02	1.05	1.07	1.10	1.13	1.16	22.31
9/16	.986	1.02	1.05	1.08	1.11	1.14	1.17	1.20	22.95

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	41/64"	21/32"	43/64"	11/16"	45/64"	23/32"	47/64"	3/4"	12"
1/16	.136	.139	.143	.146	.149	.153	.156	.159	2.53
5/64	.170	.174	.178	.183	.187	.191	.195	.199	3.19
3/32	.204	.209	.214	.219	.224	.229	.234	.239	3.83
7/64	.238	.244	.250	.256	.261	.267	.273	.279	4.46
1/8	.272	.279	.286	.292	.299	.305	.312	.319	5.10
9/64	.306	.314	.321	.329	.336	.344	.351	.359	5.74
5/32	.340	.349	.357	.365	.374	.382	.390	.398	6.38
11/64	.374	.383	.393	.402	.411	.420	.429	.438	7.01
3/16	.408	.418	.428	.438	.448	.458	.468	.478	7.65
13/64	.442	.453	.464	.475	.486	.496	.507	.518	8.29
7/32	.476	.488	.500	.511	.523	.535	.546	.558	8.93
15/64	.510	.523	.535	.548	.560	.573	.585	.598	9.56
1/4	.545	.558	.571	.584	.598	.611	.624	.638	10.20
17/64	.578	.593	.607	.621	.635	.649	.663	.677	10.84
9/32	.613	.628	.642	.657	.672	.687	.702	.717	11.48
19/64	.647	.662	.678	.694	.710	.725	.741	.757	12.11
5/16	.681	.697	.714	.730	.747	.764	.780	.797	12.75
21/64	.715	.732	.750	.767	.784	.802	.819	.827	13.39
11/32	.749	.767	.785	.804	.822	.840	.858	.877	14.03
23/64	.783	.802	.821	.840	.859	.878	.897	.916	14.66
3/8	.817	.837	.857	.877	.896	.916	.936	.956	15.30
25/64	.851	.872	.892	.913	.934	.955	.975	.996	15.94
13/32	.885	.906	.928	.950	.971	.993	1.01	1.04	16.58
27/64	.919	.941	.964	.986	1.01	1.03	1.05	1.08	17.21
7/16	.953	.976	.999	1.02	1.05	1.07	1.09	1.12	17.85
29/64	.987	1.01	1.04	1.06	1.08	1.11	1.13	1.16	18.49
15/32	1.02	1.05	1.07	1.10	1.12	1.15	1.17	1.20	19.13
31/64	1.06	1.08	1.11	1.13	1.16	1.18	1.21	1.24	19.76
1/2	1.09	1.12	1.14	1.17	1.20	1.22	1.25	1.28	20.40
33/64	1.12	1.15	1.18	1.21	1.23	1.26	1.29	1.31	21.04
17/32	1.16	1.19	1.21	1.24	1.27	1.30	1.33	1.35	21.68
35/64	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.39	22.31
9/16	1.23	1.26	1.28	1.31	1.34	1.37	1.40	1.43	22.95

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

One cubic foot of steel weighs 489.6 pounds.

For Thicknesses from $\frac{3}{16}$ in. to 2 in. and Widths from 1 in. to $12\frac{3}{4}$ in.

Thickness in Inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	12″
$\frac{3}{16}$	.638	.797	.957	1.11	1.28	1.44	1.59	1.75	7.65
$\frac{1}{4}$	.850	1.06	1.28	1.49	1.70	1.91	2.12	2.34	10.20
$\frac{5}{16}$	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	12.75
$\frac{3}{8}$	1.28	1.59	1.92	2.23	2.55	2.87	3.19	3.51	15.30
$\frac{7}{16}$	1.49	1.86	2.23	2.60	2.98	3.35	3.72	4.09	17.85
$\frac{1}{2}$	1.70	2.12	2.55	2.98	3.40	3.83	4.25	4.67	20.40
$\frac{9}{16}$	1.92	2.39	2.87	3.35	3.83	4.30	4.78	5.26	22.95
$\frac{5}{8}$	2.12	2.65	3.19	3.72	4.25	4.78	5.31	5.84	25.50
$\frac{11}{16}$	2.34	2.92	3.51	4.09	4.67	5.26	5.84	6.43	28.05
$\frac{3}{4}$	2.55	3.19	3.83	4.47	5.10	5.75	6.38	7.02	30.60
$\frac{13}{16}$	2.76	3.45	4.14	4.84	5.53	6.21	6.90	7.60	33.15
$\frac{7}{8}$	2.98	3.72	4.47	5.20	5.95	6.69	7.44	8.18	35.70
$\frac{15}{16}$	3.19	3.99	4.78	5.58	6.38	7.18	7.97	8.77	38.25
1	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	40.80
$1\frac{1}{16}$	3.61	4.52	5.42	6.32	7.22	8.13	9.03	9.93	43.35
$1\frac{1}{8}$	3.83	4.78	5.74	6.70	7.65	8.61	9.57	10.52	45.90
$1\frac{3}{16}$	4.04	5.05	6.06	7.07	8.08	9.09	10.10	11.11	48.45
$1\frac{1}{4}$	4.25	5.31	6.38	7.44	8.50	9.57	10.63	11.69	51.00
$1\frac{5}{16}$	4.46	5.58	6.69	7.81	8.93	10.04	11.16	12.27	53.55
$1\frac{3}{8}$	4.67	5.84	7.02	8.18	9.35	10.52	11.69	12.85	56.10
$1\frac{7}{16}$	4.89	6.11	7.34	8.56	9.78	11.00	12.22	13.44	58.65
$1\frac{1}{2}$	5.10	6.38	7.65	8.93	10.20	11.48	12.75	14.03	61.20
$1\frac{9}{16}$	5.32	6.64	7.97	9.30	10.63	11.95	13.28	14.61	63.75
$1\frac{5}{8}$	5.52	6.90	8.29	9.67	11.05	12.43	13.81	15.19	66.30
$1\frac{11}{16}$	5.74	7.17	8.61	10.04	11.47	12.91	14.34	15.78	68.85
$1\frac{3}{4}$	5.95	7.44	8.93	10.42	11.90	13.40	14.88	16.37	71.40
$1\frac{13}{16}$	6.16	7.70	9.24	10.79	12.33	13.86	15.40	16.95	73.95
$1\frac{7}{8}$	6.38	7.97	9.57	11.15	12.75	14.34	15.94	17.53	76.50
$1\frac{15}{16}$	6.59	8.24	9.88	11.53	13.18	14.83	16.47	18.12	79.05
2	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.70	81.60

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	12″
1/16	1.91	2.07	2.23	2.39	2.55	2.71	2.87	3.03	7.65
1/4	2.55	2.76	2.98	3.19	3.40	3.61	3.83	4.04	10.20
5/16	3.19	3.45	3.72	3.99	4.25	4.52	4.78	5.05	12.75
3/8	3.83	4.15	4.47	4.78	5.10	5.42	5.74	6.06	15.30
7/16	4.46	4.83	5.20	5.58	5.95	6.32	6.70	7.07	17.85
1/2	5.10	5.53	5.95	6.38	6.80	7.22	7.65	8.08	20.40
9/16	5.74	6.22	6.70	7.17	7.65	8.13	8.61	9.09	22.95
5/8	6.38	6.91	7.44	7.97	8.50	9.03	9.57	10.10	25.50
11/16	7.02	7.60	8.18	8.76	9.35	9.93	10.52	11.11	28.05
3/4	7.65	8.29	8.93	9.57	10.20	10.84	11.48	12.12	30.60
13/16	8.29	8.98	9.67	10.36	11.05	11.74	12.43	13.12	33.15
7/8	8.93	9.67	10.41	11.16	11.90	12.65	13.39	14.13	35.70
15/16	9.57	10.36	11.16	11.95	12.75	13.55	14.34	15.14	38.25
1	10.20	11.05	11.90	12.75	13.60	14.45	15.30	16.15	40.80
1 1/16	10.84	11.74	12.65	13.55	14.45	15.35	16.26	17.16	43.35
1 1/8	11.48	12.43	13.39	14.34	15.30	16.26	17.22	18.17	45.90
1 3/16	12.12	13.12	14.13	15.14	16.15	17.16	18.17	19.18	48.45
1 1/4	12.75	13.81	14.87	15.94	17.00	18.06	19.13	20.19	51.00
1 5/16	13.39	14.50	15.62	16.74	17.85	18.96	20.08	21.20	53.55
1 3/8	14.03	15.20	16.36	17.53	18.70	19.87	21.04	22.21	56.10
1 7/16	14.66	15.88	17.10	18.33	19.55	20.77	21.99	23.22	58.65
1 1/2	15.30	16.58	17.85	19.13	20.40	21.68	22.95	24.23	61.20
1 9/16	15.94	17.27	18.60	19.92	21.25	22.58	23.91	25.24	63.75
1 5/8	16.58	17.96	19.34	20.72	22.10	23.48	24.87	26.25	66.30
1 11/16	17.22	18.65	20.08	21.51	22.95	24.38	25.82	27.26	68.85
1 3/4	17.85	19.34	20.83	22.32	23.80	25.29	26.78	28.27	71.40
1 13/16	18.49	20.03	21.57	23.11	24.65	26.19	27.73	29.27	73.95
1 7/8	19.13	20.72	22.31	23.91	25.50	27.10	28.69	30.28	76.50
1 15/16	19.77	21.41	23.06	24.70	26.35	28.00	29.64	31.29	79.05
2	20.40	22.10	23.80	25.50	27.20	28.90	30.60	32.30	81.60

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	5″	5¼″	5½″	5¾″	6″	6¼″	6½″	6¾″	12″
3/16	3.19	3.35	3.51	3.67	3.83	3.99	4.14	4.30	7.65
1/4	4.25	4.46	4.67	4.89	5.10	5.31	5.53	5.74	10.20
5/16	5.31	5.58	5.84	6.11	6.38	6.64	6.90	7.17	12.75
3/8	6.38	6.69	7.02	7.34	7.65	7.97	8.29	8.61	15.30
7/16	7.44	7.81	8.18	8.56	8.93	9.29	9.67	10.04	17.85
1/2	8.50	8.93	9.35	9.77	10.20	10.63	11.05	11.48	20.40
9/16	9.57	10.04	10.52	11.00	11.48	11.95	12.43	12.91	22.95
5/8	10.63	11.16	11.69	12.22	12.75	13.28	13.81	14.34	25.50
11/16	11.69	12.27	12.85	13.44	14.03	14.61	15.20	15.78	28.05
3/4	12.75	13.39	14.03	14.67	15.30	15.94	16.58	17.22	30.60
13/16	13.81	14.50	15.19	15.88	16.58	17.27	17.95	18.65	33.15
7/8	14.87	15.62	16.36	17.10	17.85	18.60	19.34	20.08	35.70
15/16	15.94	16.74	17.53	18.33	19.13	19.92	20.72	21.51	38.25
1	17.00	17.85	18.70	19.55	20.40	21.25	22.10	22.95	40.80
1 1/16	18.06	18.96	19.87	20.77	21.68	22.58	23.48	24.39	43.35
1 1/8	19.13	20.08	21.04	21.99	22.95	23.91	24.87	25.82	45.90
1 3/16	20.19	21.20	22.21	23.22	24.23	25.23	26.24	27.25	48.45
1 1/4	21.25	22.32	23.38	24.44	25.50	26.56	27.62	28.69	51.00
1 5/16	22.32	23.43	24.54	25.66	26.78	27.90	29.01	30.12	53.55
1 3/8	23.38	24.54	25.71	26.88	28.05	29.22	30.39	31.56	56.10
1 7/16	24.44	25.66	26.88	28.10	29.33	30.55	31.77	32.99	58.65
1 1/2	25.50	26.78	28.05	29.33	30.60	31.88	33.15	34.43	61.20
1 9/16	26.57	27.89	29.22	30.55	31.88	33.20	34.53	35.86	63.75
1 5/8	27.63	29.01	30.39	31.77	33.15	34.53	35.91	37.29	66.30
1 11/16	28.69	30.12	31.55	32.99	34.43	35.86	37.30	38.73	68.85
1 3/4	29.75	31.24	32.73	34.22	35.70	37.19	38.68	40.17	71.40
1 13/16	30.81	32.35	33.89	35.43	36.98	38.52	40.05	41.60	73.95
1 7/8	31.87	33.47	35.06	36.65	38.25	39.85	41.44	43.03	76.50
1 15/16	32.94	34.59	36.23	37.88	39.53	41.17	42.82	44.46	79.05
2	34.00	35.70	37.40	39.10	40.80	42.50	44.20	45.90	81.60

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	7″	7¼″	7½″	7¾″	8″	8¼″	8½″	8¾″	12″
1/16	4.46	4.62	4.78	4.94	5.10	5.26	5.42	5.58	7.65
1/4	5.95	6.16	6.36	6.58	6.80	7.01	7.22	7.43	10.20
5/16	7.44	7.70	7.97	8.23	8.50	8.76	9.03	9.29	12.75
3/8	8.93	9.25	9.57	9.88	10.20	10.52	10.84	11.16	15.30
7/16	10.41	10.78	11.16	11.53	11.90	12.27	12.64	13.02	17.85
1/2	11.90	12.32	12.75	13.18	13.60	14.03	14.44	14.87	20.40
9/16	13.39	13.86	14.34	14.82	15.30	15.78	16.26	16.74	22.95
5/8	14.87	15.40	15.94	16.47	17.00	17.53	18.06	18.59	25.50
11/16	16.36	16.94	17.53	18.12	18.70	19.28	19.86	20.45	28.05
3/4	17.85	18.49	19.13	19.77	20.40	21.04	21.68	22.32	30.60
13/16	19.34	20.03	20.72	21.41	22.10	22.79	23.48	24.17	33.15
7/8	20.83	21.57	22.32	23.05	23.80	24.55	25.30	26.04	35.70
15/16	22.32	23.11	23.91	24.70	25.50	26.30	27.10	27.89	38.25
1	23.80	24.65	25.50	26.35	27.20	28.05	28.90	29.75	40.80
1 1/16	25.29	26.19	27.10	28.00	28.90	29.80	30.70	31.61	43.35
1 1/8	26.78	27.73	28.68	29.64	30.60	31.56	32.52	33.47	45.90
1 3/16	28.26	29.27	30.28	31.29	32.30	33.31	34.32	35.33	48.45
1 1/4	29.75	30.81	31.88	32.94	34.00	35.06	36.12	37.20	51.00
1 5/16	31.23	32.35	33.48	34.59	35.70	36.81	37.93	39.05	53.55
1 3/8	32.72	33.89	35.06	36.23	37.40	38.57	39.74	40.91	56.10
1 7/16	34.21	35.44	36.66	37.88	39.10	40.32	41.54	42.77	58.65
1 1/2	35.70	36.98	38.26	39.53	40.80	42.08	43.35	44.63	61.20
1 9/16	37.19	38.51	39.84	41.17	42.50	43.83	45.16	46.49	63.75
1 5/8	38.67	40.05	41.44	42.82	44.20	45.58	46.96	48.34	66.30
1 11/16	40.16	41.59	43.03	44.47	45.90	47.33	48.76	50.20	68.85
1 3/4	41.65	43.14	44.63	46.12	47.60	49.09	50.58	52.07	71.40
1 13/16	43.14	44.68	46.22	47.76	49.30	50.84	52.38	53.92	73.95
1 7/8	44.63	46.22	47.82	49.40	51.00	52.60	54.20	55.79	76.50
1 15/16	46.12	47.76	49.41	51.05	52.70	54.35	56.00	57.64	79.05
2	47.60	49.30	51.00	52.70	54.40	56.10	57.80	59.50	81.60

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	9″	9¼″	9½″	9¾″	10″	10¼″	10½″	10¾″	12″
1/16	5.74	5.90	6.06	6.22	6.38	6.54	6.70	6.86	7.65
1/4	7.65	7.86	8.08	8.29	8.50	8.71	8.92	9.14	10.20
5/16	9.56	9.83	10.10	10.36	10.62	10.89	11.16	11.42	12.75
3/8	11.48	11.80	12.12	12.44	12.75	13.07	13.39	13.71	15.30
7/16	13.40	13.76	14.14	14.51	14.88	15.25	15.62	15.99	17.85
1/2	15.30	15.73	16.16	16.58	17.00	17.42	17.85	18.28	20.40
9/16	17.22	17.69	18.18	18.65	19.14	19.61	20.08	20.56	22.95
5/8	19.13	19.65	20.19	20.72	21.25	21.78	22.32	22.85	25.50
11/16	21.04	21.62	22.21	22.79	23.38	23.96	24.54	25.13	28.05
3/4	22.96	23.59	24.23	24.86	25.50	26.14	26.78	27.42	30.60
13/16	24.86	25.55	26.24	26.94	27.62	28.32	29.00	29.69	33.15
7/8	26.78	27.52	28.26	29.01	29.75	30.50	31.24	31.98	35.70
15/16	28.69	29.49	30.28	31.08	31.88	32.67	33.48	34.28	38.25
1	30.60	31.45	32.30	33.15	34.00	34.85	35.70	36.55	40.80
1 1/16	32.52	33.41	34.32	35.22	36.12	37.03	37.92	38.83	43.35
1 1/8	34.43	35.38	36.34	37.29	38.25	39.21	40.17	41.12	45.90
1 3/16	36.34	37.35	38.36	39.37	40.38	41.39	42.40	43.40	48.45
1 1/4	38.26	39.31	40.37	41.44	42.50	43.56	44.63	45.69	51.00
1 5/16	40.16	41.28	42.40	43.52	44.64	45.75	46.86	47.97	53.55
1 3/8	42.08	43.25	44.41	45.58	46.75	47.92	49.08	50.25	56.10
1 7/16	44.00	45.22	46.44	47.66	48.88	50.10	51.32	52.54	58.65
1 1/2	45.90	47.18	48.45	49.73	51.00	52.28	53.55	54.83	61.20
1 9/16	47.82	49.14	50.48	51.80	53.14	54.46	55.78	57.11	63.75
1 5/8	49.73	51.10	52.49	53.87	55.25	56.63	58.02	59.40	66.30
1 11/16	51.64	53.07	54.51	55.94	57.38	58.81	60.24	61.68	68.85
1 3/4	53.56	55.04	56.53	58.01	59.50	60.99	62.48	63.97	71.40
1 13/16	55.46	57.00	58.54	60.09	61.62	63.17	64.70	66.24	73.95
1 7/8	57.38	58.97	60.56	62.16	63.75	65.35	66.94	68.53	76.50
1 15/16	59.29	60.94	62.58	64.23	65.88	67.52	69.18	70.83	79.05
2	61.20	62.90	64.60	66.30	68.00	69.70	71.40	73.10	81.60

WEIGHTS OF FLAT ROLLED STEEL BARS.

PER LINEAL FOOT.

(CONCLUDED.)

Thickness in Inches.	11″	11¼″	11½″	11¾″	12″	12¼″	12½″	12¾″
3/16	7.02	7.17	7.32	7.49	7.65	7.82	7.98	8.13
1/4	9.34	9.57	9.78	10.00	10.20	10.42	10.63	10.84
5/16	11.68	11.95	12.22	12.49	12.75	13.01	13.28	13.55
3/8	14.03	14.35	14.68	14.99	15.30	15.62	15.94	16.26
7/16	16.36	16.74	17.12	17.49	17.85	18.23	18.60	18.97
1/2	18.70	19.13	19.55	19.97	20.40	20.82	21.25	21.67
9/16	21.02	21.51	22.00	22.48	22.95	23.43	23.90	24.39
5/8	23.38	23.91	24.44	24.97	25.50	26.03	26.56	27.09
11/16	25.70	26.30	26.88	27.47	28.05	28.64	29.22	29.80
3/4	28.05	28.68	29.33	29.97	30.60	31.25	31.88	32.52
13/16	30.40	31.08	31.76	32.46	33.15	33.83	34.53	35.22
7/8	32.72	33.47	34.21	34.95	35.70	36.44	37.19	37.93
15/16	35.06	35.86	36.66	37.46	38.25	39.05	39.84	40.64
1	37.40	38.25	39.10	39.95	40.80	41.65	42.50	43.35
1 1/16	39.74	40.64	41.54	42.45	43.35	44.25	45.16	46.06
1 1/8	42.08	43.04	44.00	44.94	45.90	46.86	47.82	48.77
1 3/16	44.42	45.42	46.44	47.45	48.45	49.46	50.46	51.48
1 1/4	46.76	47.82	48.88	49.94	51.00	52.06	53.12	54.19
1 5/16	49.08	50.20	51.32	52.44	53.55	54.67	55.78	56.90
1 3/8	51.42	52.59	53.76	54.93	56.10	57.27	58.44	59.60
1 7/16	53.76	54.99	56.21	57.43	58.65	59.87	61.10	62.32
1 1/2	56.10	57.37	58.65	59.93	61.20	62.48	63.75	65.03
1 9/16	58.42	59.76	61.10	62.43	63.75	65.08	66.40	67.74
1 5/8	60.78	62.16	63.54	64.92	66.30	67.68	69.06	70.44
1 11/16	63.10	64.55	65.98	67.42	68.85	70.29	71.72	73.15
1 3/4	65.45	66.93	68.43	69.92	71.40	72.90	74.38	75.87
1 13/16	67.80	69.33	70.86	72.41	73.95	75.48	77.03	78.57
1 7/8	70.12	71.72	73.31	74.90	76.50	78.09	79.69	81.28
1 15/16	72.46	74.11	75.76	77.41	79.05	80.70	82.34	83.99
2	74.80	76.50	78.20	79.90	81.60	83.30	85.00	86.70

The weights for 12″ width are repeated on each page to facilitate making the additions necessary to obtain the weights of plates of any width greater than 12″. Thus, to find the weight of 15¾″ × ⅜″, add the weights to be found in the same line for 3¾ × ⅜ and 12 × ⅜ = 10.41 + 35.70 = 46.11 pounds. Weight of plate 4′ 6½″ × ⅝″ = 4 × 25.50 + 13.81 = 115.81 pounds.

WEIGHTS AND MEASURES.

AVOIRDUPOIS WEIGHT.

UNITED STATES AND BRITISH.

Grains.	Drams.	Ounces.	Pounds.	Hundred-weight.	Gross Tons.
1.	.03657	.002286	.000143	.00000128	.000000176
27.34375	1.	.0625	.003906	.00003488	.000001744
437.5	16.	1.	.0625	.00055804	.00002790
7000.	256.	16.	1.	.0089286	.0004464
784000.	28672.	1792.	112.	1.	.05
5680000.	573440.	35840.	2240.	20.	1.

1 pound avoirdupois = 1.215278 pounds troy.
1 net ton = 2000 pounds = .892857 gross ton.

TROY WEIGHT.

UNITED STATES AND BRITISH.

Grains.	Pennyweight.	Ounces.	Pounds.
1	.041667	.0020833	.0001736
24	1.	.05	.0041667
480	20.	1.	.0833333
5760	240.	12.	1.

1 pound troy = .822857 pound avoirdupois.
175 ounces troy = 192 ounces avoirdupois.

APOTHECARIES' WEIGHT.

UNITED STATES AND BRITISH.

Grains.	Scruples.	Drams.	Ounces.	Pounds.
1	.05	.016667	.0020833	.000173611
20	1.	.333333	.0416667	.0034722
60	3.	1.	.125	.0104167
480	24.	8.	1.	.0833333
5760	288.	96.	12.	1.

The pound, ounce and grain are the same as in troy weight.
The avoirdupois grain = troy grain = apothecaries' grain.

WEIGHTS AND MEASURES—Continued.

LINEAR MEASURE.

UNITED STATES AND BRITISH.

Inches.	Feet.	Yards.	Rods.	Furlong.	Miles.
1	.08333	.02778	.0050505	.00012626	.00001578
12	1.	.33333	.0606061	.00151515	.00018939
36	3.	1.	.1818182	.00454545	.00056818
198	16.5	5.5	1.	.025	.003125
7920	660.	220.	40.	1.	.125
63360	5280.	1760.	320.	8.	1.

ROPE AND CABLE MEASURE.

1 inch = .111111 span = .013889 fathom = .0001157 cable's length.
1 span = 9 inches = .125 fathom = .00104167 cable's length.
1 fathom = 6 feet = 8 spans = 72 inches = .008333 cable's length.
1 cable's length = 120 fathoms = 720 feet = 960 spans = 8640 inches.

NAUTICAL MEASURE.

1 nautical mile, as adopted by the United States Coast and Geodetic Survey, equals the length of one minute of arc of a great circle of a sphere whose surface equals that of the earth = 6080.204 feet = 1.1516 statute miles.

1 league = 3 nautical miles = 18240.613 feet.

GUNTER'S CHAIN.

1 link = 7.92 inches = .01 chain = .000125 mile.
1 chain = 100 links = 66 feet = 4 rods = .0125 mile.
1 mile = 80 chains = 8000 links.

SQUARE OR LAND MEASURE.

UNITED STATES AND BRITISH.

Square Inches.	Square Feet.	Square Yards.	Square Rods.	Acres.	Square Miles.
1	.006944	.0007716	. . . . .	. . . . .	. . . . .
144	1.	.111111	. . . . .	. . . . .	. . . . .
1296	9.0	1.	.03306	.0002066	. . . . .
39204	272.25	30.25	1.	.00625	.00000977
6272640	43560.	4840.	160.	1.	.0015625
	27878400.	3097600.	102400.	640.	1.

1 square rood = 40 square rods.
1 acre = 4 square roods.
1 square acre = 208.71 feet square.

WEIGHTS AND MEASURES—Continued.

CUBIC OR SOLID MEASURE.

UNITED STATES AND BRITISH.

1 cubic inch = .0005787 cubic foot = .000021433 cubic yard.

1 cubic foot = 1728 cubic inches = .03703704 cubic yard.

1 cubic yard = 27 cubic feet = 46656 cubic inches.

1 cord of wood = 128 cubic feet = 4 feet by 4 feet by 8 feet.

1 perch of masonry = 24.75 cubic feet = 16.5 feet by 1.5 feet by 1 foot. It is usually taken as 25 cubic feet.

DRY MEASURE.

UNITED STATES ONLY.

Pints.	Quarts.	Gallons.	Pecks.	Bushels.	Cubic Inches.
1	.50	.125	.0625	.015625	33.6003125
2	1.	.25	.125	.03125	67.200625
8	4.	1.	.05	.125	268.8025
16	8.	2.	1.	.25	537.605
64	32.	8.	4.	1.	2150.42

1 heaped bushel = 1.25 struck bushel, and the cone must be not less than 6 inches high.

LIQUID MEASURE.

UNITED STATES ONLY.

Gills.	Pints.	Quarts.	Gallons.	Barrels.	Cubic Inches.
1	.25	.125	.03125	.000498	7.21875
4	1.	.5	.125	.003968	28.875
8	2.	1.	.25	.007937	57.75
32	8.	4.	1.	.031746	231.
2008	252.	126.	31.5	1.	7276.5

The British imperial gallon = 277.274 cubic inches or 10 pounds avoirdupois of pure water at 62° F. and barometer at 30 inches.

The British imperial gallon = 1.20032 United States gallons.

1 fluid drachm = 60 minims = .125 fluid ounce = .0078125 pint.

1 fluid ounce = 480 minims = 8 drachms = .0625 pint.

WEIGHTS AND MEASURES—Concluded.

METRIC SYSTEM.

MEASURES OF LENGTH, CAPACITY AND WEIGHT.

LENGTH.	Kilometre.	Hecto-metre.	Decametre.	Metre.	Decimetre.	Centimetre.	Millimetre.
CAPACITY.	Kilolitre or Stere.	Hectolitre or Decistere.	Decalitre or Centistere.	Litre or Millistere.	Decilitre.	Centilitre.	Millilitre.
WEIGHT.	Kilo-gramme.	Hecto-gramme.	Deca-gramme.	Gramme.	Decigramme.	Centi-gramme.	Milli-gramme.
	1	10	100	1000	10000	100000	1000000
		1	10	100	1000	10000	100000
			1	10	100	1000	10000
				1	10	100	1000
				.1	1	10	100
				.01	.1	1	10
				.001	.01	.1	1

1 myriametre = 10 kilometres = 10000 metres.
1 tonne = 1000 kilogrammes = 100 quintals = 10 myriagrammes.
1 gramme = 1 cubic centimetre of distilled water at its maximum density at sea level in latitude of Paris and barometer at 760 millimetres.
1 litre = 1 cubic decimeter.

METRIC SYSTEM.

SQUARE OR SURFACE MEASURE.

Square Kilometre.	Square Hectometre or Hectare.	Square Decametre or Are.	Square Metre or Centiare.	Square Decimetre.	Square Centimetre.	Square Millimetre.
1	100	10000	1000000			
	1	100	10000	1000000		
	.01	1	100	10000	1000000	
	.0001	.01	1	100	10000	1000000
	.00001	.0001	.01	1	100	10000
		.000001	.0001	.01	1	100
			.000001	.0001	.01	1

1 square myriametre = 100 square kilometres = 100 000 000 square metres.

METRIC SYSTEM.

CUBIC MEASURE.

Cubic Decametre.	Cubic Metre.	Cubic Decimetre.	Cubic Centimetre.	Cubic Millimetre.
1	1000	1000000	1000000000	
.001	1	1000	1000000	1000000000
.000001	.001	1	1000	1000000
.000000001	.000001	.001	1	1000
	.000000001	.000001	.001	1

1 cubic metre = 1 kilolitre = 1 stere.

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES.

CUSTOMARY TO METRIC.

Weights.

No.	Grains to Milligrammes.	Troy Ounces to Grammes.	Avoirdupois Ounces to Grammes.	Avoirdupois Pounds to Kilogrammes.	Net Tons of 2000 Pounds to Tonnes.	Gross Tons of 2240 Pounds to Tonnes.
1	64.79892	31.10348	28.34953	.45359	.90718	1.01605
2	129.59784	62.20696	56.69905	.90718	1.81437	2.03209
3	194.39675	93.31044	85.04858	1.36078	2.75155	3.04814
4	259.19567	124.41392	113.39811	1.81437	3.62874	4.06419
5	323.99459	155.51740	141.74763	2.26796	4.53592	5.08024
6	388.79351	186.62088	170.09716	2.72155	5.44311	6.09628
7	453.59243	217.72437	198.44669	3.17515	6.35029	7.11233
8	518.39135	248.82785	226.79621	3.62874	7.25748	8.12838
9	583.19026	279.93133	255.14574	4.08233	8.16466	9.14442

1 Avoirdupois Pound = 453.5924277 Grammes.

Linear Measure.

No.	64ths of an Inch to Millimetres.	Inches to Centimetres.	Feet to Metres.	Yards to Metres.	Statute Miles to Kilometres.	Nautical Miles to Kilometres.
1	.39688	2.54001	.304801	.914402	1.60935	1.85325
2	.79375	5.08001	.609601	1.828804	3.21869	3.70650
3	1.19063	7.62002	.914402	2.743205	4.82804	5.55975
4	1.58750	10.16002	1.219202	3.657607	6.43739	7.41300
5	1.98438	12.70003	1.524003	4.572009	8.04674	9.26625
6	2.38125	15.24003	1.828804	5.486411	9.65608	11.11950
7	2.77813	17.78004	2.133604	6.400813	11.26543	12.97275
8	3.17501	20.32004	2.438405	7.315215	12.87478	14.82600
9	3.57188	22.86005	2.743205	8.229616	14.48412	16.67925

1 Nautical Mile = 1853.25 Metres.
1 Gunter's Chain = 20.1168 Metres.
1 Fathom = 1.829 Metres.

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES.

METRIC TO CUSTOMARY.

Weights.

No.	Milligrammes to Grains.	Grammes to Troy Ounces.	Grammes to Avoirdupois Ounces.	Kilogrammes to Avoirdupois Pounds.	Tonnes to Net Tons of 2000 Pounds.	Tonnes to Gross Tons of 2240 Pounds.
1	.01543	.03215	.03527	2.20462	1.10231	.98421
2	.03086	.06430	.07055	4.40924	2.20462	1.96841
3	.04630	.09645	.10582	6.61387	3.30693	2.95262
4	.06173	.12860	.14110	8.81849	4.40924	3.93682
5	.07716	.16075	.17637	11.02311	5.51156	4.92103
6	.09259	.19290	.21164	13.22773	6.61387	5.90524
7	.10803	.22506	.24692	15.43236	7.71618	6.88944
8	.12346	.25721	.28219	17.63698	8.81849	7.87365
9	.13889	.28936	.31747	19.84160	9.92080	8.85785

1 Kilogramme = 15432.35639 Grains.

Linear Measure.

No.	Millimetres to 64ths of an Inch.	Centimetres to Inches.	Metres to Feet.	Metres to Yards.	Kilometres to Statute Miles.	Kilometres to Nautical Miles.
1	2.51963	.39370	3.280833	1.093611	.62137	.53959
2	5.03936	.78740	6.561667	2.187222	1.24274	1.07919
3	7.55904	1.18110	9.842500	3.280833	1.86411	1.61878
4	10.07872	1.57480	13.123333	4.374444	2.48548	2.15837
5	12.59840	1.96850	16.404167	5.468056	3.10685	2.69796
6	15.11808	2.36220	19.685000	6.561667	3.72822	3.23756
7	17.63776	2.75590	22.965833	7.655278	4.34959	3.77715
8	20.15744	3.14960	26.246667	8.748889	4.97096	4.31674
9	22.67712	3.54330	29.527500	9.842500	5.59233	4.85633

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES.

CUSTOMARY TO METRIC.

Square Measure.

No.	Square Inches to Square Centimetres.	Square Feet to Square Metres.	Square Yards to Square Metres.	Acres to Hectares.	Square Miles to Square Kilometres.
1	6.45163	.09290	.83613	.40470	2.59000
2	12.90325	.18581	1.67226	.80939	5.18000
3	19.35488	.27871	2.50839	1.21409	7.77000
4	25.80650	.37161	3.34452	1.61879	10.35999
5	32.25813	.46452	4.18065	2.02349	12.94999
6	38.70975	.55742	5.01679	2.42818	15.53999
7	45.16138	.65032	5.85292	2.83288	18.12999
8	51.61300	.74323	6.68905	3.23758	20.71999
9	58.06463	.83613	7.52518	3.64228	23.30999

1 Square Statute Mile = 259.00 Hectares.

Cubic Measure.

No.	Cubic Inches to Cubic Centimetres.	Cubic Inches to Cubic Decimetres.	Cubic Feet to Cubic Metres.	Cubic Yards to Cubic Metres.
1	16.38716	.01639	.02832	.76456
2	32.77432	.03277	.05663	1.52912
3	49.16148	.04916	.08495	2.29368
4	65.54864	.06555	.11327	3.05824
5	81.93580	.08194	.14159	3.82280
6	98.32296	.09832	.16990	4.58736
7	114.71013	.11471	.19822	5.35192
8	131.09729	.13110	.22654	6.11648
9	147.48445	.14748	.25485	6.88104

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES.

METRIC TO CUSTOMARY.

Square Measure.

No.	Square Centimetres to Square Inches.	Square Metres to Square Feet.	Square Metres to Square Yards.	Hectares to Acres.	Square Kilometres to Square Miles.
1	.15500	10.76387	1.19599	2.47104	.38610
2	.31000	21.52773	2.39197	4.94209	.77220
3	.46500	32.29160	3.58796	7.41313	1.15830
4	.62000	43.05547	4.78394	9.88418	1.54440
5	.77500	53.81934	5.97993	12.35522	1.93050
6	.93000	64.58320	7.17591	14.82626	2.31660
7	1.08500	75.34707	8.37190	17.29731	2.70270
8	1.24000	86.11094	9.56788	19.76835	3.08880
9	1.39500	96.87481	10.76387	22.23940	3.47490

1 Hectare = .003861 Square Statute Mile.

Cubic Measure.

No.	Cubic Centimetres to Cubic Inches.	Cubic Decimetres to Cubic Inches.	Cubic Metres to Cubic Feet.	Cubic Metres to Cubic Yards.
1	.06102	61.02338	35.31445	1.30794
2	.12205	122.04676	70.62891	2.61589
3	.18207	183.07013	105.94336	3.92383
4	.24409	244.09351	141.25782	5.23177
5	.30512	305.11689	176.57227	6.53971
6	.36614	366.14027	211.88673	7.84766
7	.42716	427.16365	247.20118	9.15560
8	.48819	488.18702	282.51564	10.46354
9	.54921	549.21040	317.83009	11.77149

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES.

CUSTOMARY TO METRIC.

Capacity Measures.

No.	Liquid Quarts to Litres.	Gallons to Litres.	Gallons to Cubic Metres.	Bushels to Hectolitres.	Fluid Drachms to Millilitres or Cubic Centimetres.	Fluid Ounces to Millilitres or Cubic Centimetres.
1	.94636	3.78543	.00379	.35239	3.69671	29.57370
2	1.89272	7.57087	.00757	.70479	7.39343	59.14741
3	2.83908	11.35630	.01136	1.05718	11.09014	88.72111
4	3.78543	15.14174	.01514	1.40957	14.78685	118.29482
5	4.73179	18.92717	.01893	1.76196	18.48357	147.86852
6	5.67815	22.71260	.02271	2.11436	22.18028	177.44222
7	6.62451	26.49804	.02650	2.46675	25.87699	207.01593
8	7.57087	30.28347	.03028	2.81914	29.57370	236.58963
9	8.51723	34.06891	.03407	3.17154	33.27042	266.16334

Miscellaneous.

No.	Pounds per Lineal Foot to Kilogrammes per Lineal Metre.	Pounds per Square Inch to Kilogrammes per Square Centimetre.	Pounds per Square Foot to Kilogrammes per Square Metre.	Pounds per Cubic Foot to Kilogrammes per Cubic Metre.	Foot-Pounds to Kilogramme-Metres.	United States Horsepower to Metric Horsepower.
1	1.48816	.07031	4.88241	16.01837	.13826	1.01387
2	2.97632	.14061	9.76482	32.03674	.27651	2.02775
3	4.46448	.21092	14.64723	48.05510	.41477	3.04162
4	5.95264	.28123	19.52963	64.07348	.55302	4.05549
5	7.44081	.35153	24.41204	80.09185	.69128	5.06937
6	8.92897	.42184	29.29445	96.11021	.82953	6.08324
7	10.41713	.49215	34.17686	112.12858	.96779	7.09711
8	11.90529	.56245	39.05927	128.14695	1.10604	8.11098
9	13.39345	.63276	43.94168	144.16532	1.24430	9.12486

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES.

METRIC TO CUSTOMARY.

Capacity Measures.

No.	Litres to Fluid Quarts.	Litres to Gallons.	Cubic Metres to Gallons.	Hectolitres to Bushels	Millilitres or Cubic Centimetres to Fluid Drachms.	Millilitres or Cubic Centimetres to Fluid Ounces.
1	1.05668	.26417	264.17047	2.83774	.27051	.03381
2	2.11336	.52834	528.34093	5.67548	.54102	.06763
3	3.17005	.79251	792.51140	8.51323	.81153	.10144
4	4.22673	1.05668	1056.68187	11.35097	1.08204	.13526
5	5.28341	1.32085	1320.85234	14.18871	1.35255	.16907
6	6.34009	1.58502	1585.02280	17.02645	1.62306	.20288
7	7.39677	1.84919	1849.19327	19.86420	1.89357	.23670
8	8.45345	2.11336	2113.36374	22.70194	2.16408	.27051
9	9.51014	2.37753	2377.53420	25.53968	2.43460	.30432

Miscellaneous.

No.	Kilogrammes per Lineal Metre to Pounds per Lineal Foot.	Kilogrammes per Square Centimetre to Pounds per Square Inch.	Kilogrammes per Square Metre to Pounds per Square Foot.	Kilogrammes per Cubic Metre to Pounds per Cubic Foot.	Kilogramme-Metres to Foot-Pounds.	Metric Horsepower to United States Horsepower.
1	.67197	14.22340	.20482	.06243	7.23300	.98632
2	1.34393	28.44680	.40963	.12486	14.46600	1.97264
3	2.01590	42.67020	.61445	.18728	21.69899	2.95895
4	2.68787	56.89359	.81927	.24971	28.93199	3.94527
5	3.35984	71.11699	1.02408	.31214	36.16499	4.93159
6	4.03180	85.34039	1.22890	.37457	43.39799	5.91791
7	4.70377	99.56379	1.43372	.43700	50.63098	6.90423
8	5.37574	113.78719	1.63854	.49943	57.86398	7.89054
9	6.04770	128.01059	1.84335	.56185	65.09698	8.87686

MENSURATION.

Length.

Circumference of circle = diameter × 3.1416.

Diameter of circle = circumference × 0.3183.

Side of square of equal periphery as circle = diameter × 0.7854.

Diameter of circle of equal periphery as square = side × 1.2732.

Side of an inscribed square = diameter of circle × 0.7071.

Length of arc = No. of degrees × diameter × 0.008727.

Circumference of circle whose diameter is 1 =

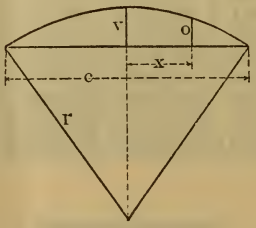
$$\pi = 3.14159265.$$

$\log. \pi = 0.4971499$

$\sqrt{\pi} = 1.772454$

$\pi^2 = 9.869604$

$$r = \frac{v^2 + \frac{c^2}{4}}{2v}$$



$\frac{1}{\pi} = 0.318310$

$\frac{1}{\pi^2} = 0.101321$

$\sqrt{\frac{1}{\pi}} = 0.564190$

or very nearly, $= \frac{c^2}{8v}$

$$o = \sqrt{r^2 - x^2} - (r - v)$$

$$v = r - \sqrt{r^2 - \frac{c^2}{4}};$$ or, very nearly, $= \frac{c^2}{8r}$

Area.

Triangle = base × half perpendicular height.

Parallelogram = base × perpendicular height.

Trapezoid = half the sum of the parallel sides × perpendicular height.

Trapezium, found by dividing into two triangles.

Circle = diameter squared × 0.7854; or, = circumference squared × 0.07958.

Sector of circle = length of arc × half radius.

Segment of circle = area of sector of equal radius — triangle when segment is less, and + triangle when segment is greater than the semicircle; also for flat segments very nearly =

$$\frac{4v}{3}\sqrt{0.388\,v^2+\frac{c^2}{4}}$$

Side of square of equal area as circle = diameter × 0.8862; also, = circumference × 0.2821.

Diameter of circle of equal area as square = side × 1.1284.

Parabola = base × $\frac{2}{3}$ height.

Ellipse = long diameter × short diameter × 0.7854.

Regular polygon = sum of sides × half perpendicular distance from center to sides.

Cylinder = circumference × height + area of both ends.

Sphere = diameter squared × 3.1416;
also, = circumference × diameter.

Segment of sphere = height of segment × circumference of sphere of which it is a part + area of base.

Right pyramid or cone = periphery or circumference of base × half slant height.

Frustum of a regular right pyramid or cone = sum of peripheries or circumferences of the two ends × half slant height + area of both ends.

Solid Contents.

Prism, right or oblique, = area of base × perpendicular height.

Cylinder, right or oblique, = area of section at right angles to sides × length of side.

Sphere = diameter cubed × 0.5236; also, = surface × $\frac{1}{6}$ diameter.

Segment of sphere = (height squared + three times the square of radius of base) × (height × 0.5236).

Side of an equal cube = diameter of sphere × 0.806.

Length of an equal cylinder = diameter of sphere × 0.6667.

Pyramid or cone, right or oblique, regular or irregular, = area of base × $\frac{1}{3}$ perpendicular height.

Frustum of cone = multiply area of two ends together, extract the square root; add to this root the two areas and × $\frac{1}{3}$ altitude.

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